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Patching EAF-2010 into CINDER2008 Cross Section Libraries

Wei Lu
Franz X. Gallmeier

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September, 2016

OAK RIDGE NATIONAL LABORATORY
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ORNL/TM-2018/16

Neutron Technologies Division

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Wei Lu and Franz X. Gallmeier

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ABSTRACT

CINDER2008 [1] comes with multi-group cross section libraries using most recent evaluated cross section data. The multi-group cross sections are weighted with three spectra: fission, fusion and flat. However, due to data format incompatibilities with the CINDER2008 library maker tool, many of the reaction cross sections adapted from EAF-2010 [2] are either truncated or completely missing. Therefore it is essential to regenerate the CINDER2008 libraries with compatible EAF-2010 data. The updated cross section libraries are compared to those of the current cross section libraries in the sections below following a brief introduction of the CINDER2008 cross section libraries and a description of the method of generating cross sections for the CINDER2008 code. In the remainder of this document, we will refer to the libraries distributed with CINDER2008 before October 2016 as the "current" libraries, and those described in this work as the "updated" libraries. In figures, the current library data may be shown with the library name with or without “cur” appended, while the updated library data may be shown with "mod" appended.

1. CINDER2008 CROSS SECTION LIBRARIES AND THEIR PROBLEM

The cross section libraries distributed with CINDER2008 are significantly changed from those distributed with its previous version, CINDER'90 [3]. Most of the cross sections are updated with most recent evaluated cross section data from ENDF VII [4], EAF-2010 and JENDL 4.0 and 3.1 [5]. The total number of nuclides included has gone from 3400 in CINDER'90 to 4084 in CINDER2008. The cross section libraries include reaction cross sections, decay gamma spectra, decay ratios, fission cross sections, fission product yield and hazardous material categories. However, in this report only the reaction cross sections are discussed. The multi-group reaction cross sections in CINDER2008 are provided in three separate libraries, as weighted by different neutron spectra (fission, fusion, and flat), in order to make calculations more accurate in different radiation environments. Both the fission and flat cross section libraries cover the same energy range (1E-11 - 25 MeV), but the flat library has a much more refined energy bin structure: 321 groups rather than 66. The fission library group structure for CINDER2008 is changed from the CINDER'90 library only by subdividing the lowest-energy CINDER'90 group (1E-11 - 5E-9 MeV) into four groups covering the same energy range. Although the fusion library covers seemingly the similar energy range (1E-11 - 19.64 MeV) with 175 energy groups, its lowest energy group spans 4 orders of magnitude (1E-11 – 1E-7 MeV).

Among the 4084 nuclides in the CINDER2008 libraries, the majority of them, 3265 nuclides, have no reaction cross sections, only decay information, etc. The remaining 819 nuclides have reaction cross sections from EAF-2010, ENDF-VII, and JENDL (both 4.0 and 3.1). The distribution of the evaluated cross section data source for the reaction cross section is listed in Table 1, where “mixed libs” means the reaction cross sections for a certain nuclide come from some combination of ENDF VII, JENDL 4.0 and 3.1. However, none of the nuclides adopting the EAF-2010 cross section uses other evaluated data source.

Table 1. Distribution of the evaluated cross section data sources in CINDER2008 libraries.

C.S. library	Nuclide number
None	3265
EAF-2010	386
ENDF VII	162
JENDL 4.0	138
Mixed libs	113
JENDL 3.1	20

Although EAF-2010 is the largest contributor to the nuclides whose reaction cross sections are not found either in ENDF VII or JENDL, it is found that in the current CINDER2008 cross section libraries many of the reaction cross sections are truncated in the fusion and flat libraries. Fig. 1 shows such an example for the (n, G) reaction of O18. The fusion cross sections in Fig. 1 are truncated around 0.6 MeV while the flat ones are truncated around 10 MeV. This may be due to the fact that the cross section data format of EAF-2010 used for importing into the CINDER2008 code was not compatible with the library maker tool of the code. Regardless, this leaves a serious impact on the accuracy of the CINDER2008 cross section libraries. The reaction cross sections for all 386 nuclides coming from EAF-2010 must therefore be regenerated. Table 2 shows the full list of the 386 nuclides in the CINDER2008 libraries coming from EAF-2010.

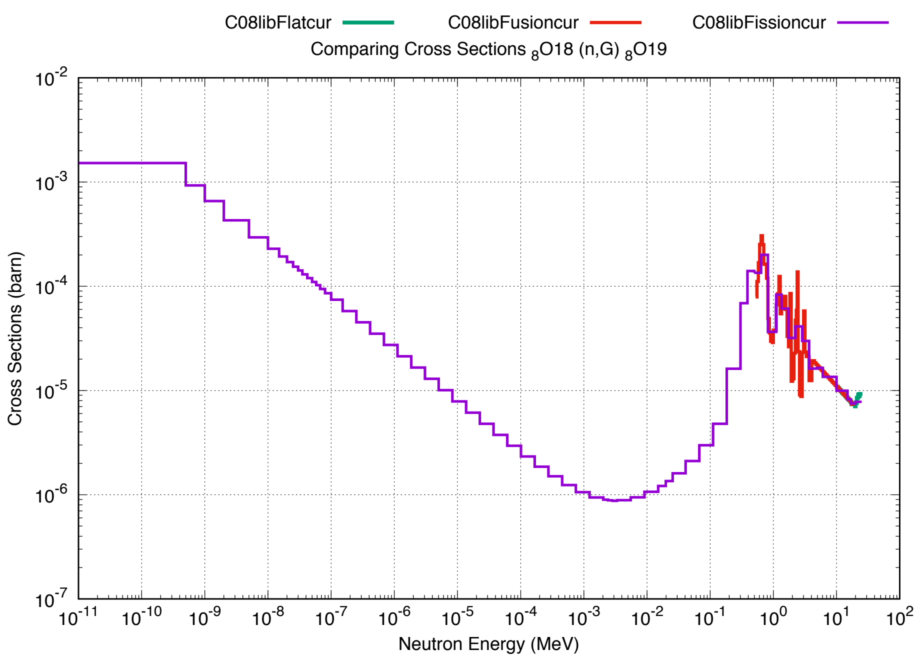


Figure 1. (n, G) reaction cross section for O18 in the current CINDER2008 cross section libraries, where the fusion and flat spectra are truncated around 0.6 and 10 MeV, respectively.

Table 2. List of 386 nuclides in CINDER2008 libraries with reaction cross sections from EAF-2010 (m1 and m2 stands for 1st and 2nd metastable state, respectively).

Be7	Be10	C12	C13	C14	O18	Ne20	Ne21	Ne22	Na24
Mg28	Al26	Si31	Si32	P32	P33	S35	Cl36	Ar37	Ar39

Ar41	Ar42	K42	K43	Ca41	Ca45	Ca47	Sc44m1	Sc46	Sc47
Sc48	Ti44	Ti45	V48	V49	Cr48	Cr51	Mn52	Mn53	Mn54
Fe52	Fe55	Fe60	Co55	Co56	Co57	Co60	Ni56	Ni57	Ni63
Ni66	Cu64	Cu67	Zn62	Zn69m1	Zn72	Ga66	Ga67	Ga72	Ge68
Ge69	Ge71	Ge77	As71	As72	As73	As76	As77	Se72	Se73
Se75	Br76	Br77	Br82	Kr76	Kr79	Kr81	Rb82m1	Rb83	Rb84
Sr82	Sr83	Sr85	Sr91	Y86	Y87	Y87m1	Y88	Y93	Zr86
Zr88	Zr89	Zr97	Nb90	Nb91	Nb91m1	Nb92	Nb92m1	Nb93m1	Nb95m1
Nb96	Mo93	Mo93m1	Tc95	Tc95m1	Tc96	Tc97	Tc97m1	Tc98	Tc99m1
Ru97	Rh99	Rh99m1	Rh100	Rh101	Rh101m1	Rh102	Rh102m1	Pd100	Pd101
Pd103	Pd109	Pd112	Ag105	Ag106m1	Ag108m1	Cd107	Cd109	Cd113m1	Cd115
In111	In114m1	Sn117m1	Sn119m1	Sn121	Sn121m1	Sb119	Sb120m1	Sb122	Sb127
Sb128	Te118	Te119	Te119m1	Te121	Te121m1	Te123m1	Te125m1	Te127	Te129
Te131m1	I123	I124	I125	I126	I128	I133	Xe122	Xe125	Xe127
Xe129m1	Xe131m1	Xe133m1	Cs127	Cs129	Cs131	Cs132	Ba128	Ba129	Ba131
Ba133m1	Ba135m1	Ba139	La135	La137	La141	Ce134	Ce135	Ce137	Ce137m1
Nd140	Nd141	Nd149	Pm143	Pm144	Pm145	Pm146	Pm150	Sm145	Sm146
Sm156	Eu145	Eu146	Eu147	Eu148	Eu149	Eu150	Eu150m1	Eu152m1	Gd146
Gd147	Gd148	Gd149	Gd150	Gd151	Gd159	Tb151	Tb152	Tb153	Tb154
Tb154m1	Tb154m2	Tb155	Tb156	Tb156m1	Tb156m2	Tb157	Tb158	Tb161	Dy153
Dy155	Dy157	Dy165	Dy166	Ho163	Ho164	Ho164m1	Ho166	Ho166m1	Er160
Er161	Er165	Er169	Er171	Er172	Tm165	Tm166	Tm167	Tm168	Tm170
Tm171	Tm172	Tm173	Yb166	Yb169	Yb175	Lu169	Lu170	Lu171	Lu172
Lu173	Lu174	Lu174m1	Lu177	Lu177m1	Hf170	Hf171	Hf172	Hf173	Hf175
Hf178m2	Hf179m2	Hf180m1	Ta175	Ta176	Ta177	Ta179	Ta180	Ta180m1	Ta183
Ta184	W178	W181	W185	W187	W188	Re181	Re182	Re182m1	Re183
Re184	Re184m1	Re186	Re186m1	Re188	Re189	Os182	Os183	Os183m1	Os185
Os191	Os191m1	Os193	Os194	Ir185	Ir186	Ir187	Ir188	Ir189	Ir190
Ir192	Ir192m2	Ir193m1	Ir194	Ir194m2	Ir196m1	Pt188	Pt189	Pt190	Pt191
Pt192	Pt193	Pt193m1	Pt194	Pt195	Pt195m1	Pt196	Pt197	Pt198	Pt200
Pt202	Au193	Au194	Au195	Au196	Au196m2	Au198	Au198m1	Au199	Au200m1
Hg193	Hg193m1	Hg194	Hg195	Hg195m1	Hg197	Hg197m1	Hg203	Tl199	Tl200
Tl201	Tl202	Tl203	Tl204	Tl205	Pb200	Pb201	Pb202	Pb203	Pb205
Pb209	Pb210	Pb212	Bi203	Bi204	Bi205	Bi206	Bi207	Bi208	Bi210
Bi210m1	Po206	Po207	Po208	Po209	Po210	At210	At211	Rn211	Rn222
Ra228	Ac228	Pa228	Pa234	Np236m1	Pu234	Pu245	Pu247	Am239	Bk248m1
Es250	Es256m1	Es257	Fm252	Fm253	Fm257				

2. METHOD OF REPATCHING EAF-2010 INTO CINDER2008 CROSS SECTION LIBS.

The correct ENDF formatted EAF-2010 cross section data were downloaded from the t2 website [6]. The point-wise cross section data were then converted into group-weighted cross sections using NJOY99 [7-11] according to the energy structures of the fission, fusion and flat spectra in CINDER2008 libraries. The main module of NJOY99 used for this conversion is GROUPR, while MODER, RECONR, BROADR and UNRESR were used for preparing the cross section data for the GROUPR module. The cross section libraries for CINDER2008 were finally generated with its included library maker tool.

3. RESULTS

3.1 FISSION-WEIGHTED LIBRARY

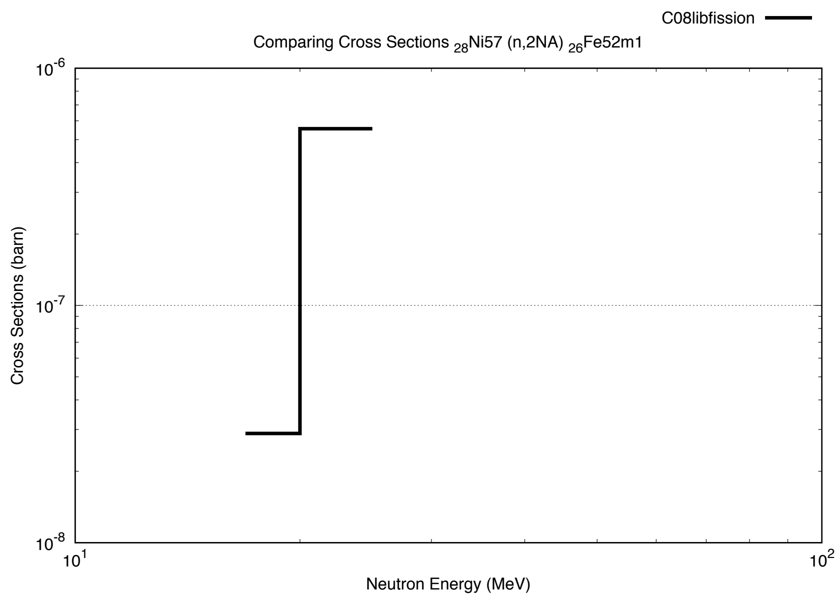
While the fission cross section library does not show obvious problems in the current CINDER2008 version, the updated version serves as a good reference point for checking the consistency of the EAF-2010 data and the correctness of the cross section generating method. Comparisons of the current and updated CINDER2008 fission-weighted cross section libraries do, however, show some inconsistency, as discussed below.

There are 37 reaction cross sections, listed in Table 3, which are in the current CINDER2008 fission-weighted library but are missing in the updated CINDER2008 one. Among them there are 29 reactions marked (*) verified to not be present in EAF-2010. The four reactions marked (†) in Table 3 are present in EAF-2010 with cross sections in the current CINDER2008 fission-weighted library shown in Figure 2. However, the EAF-2010 libraries as of July 22, 2016 show reaction threshold energies above the upper energy limit (25 MeV) of the fission group structure, and are thus not present in the updated CINDER2008 libraries.

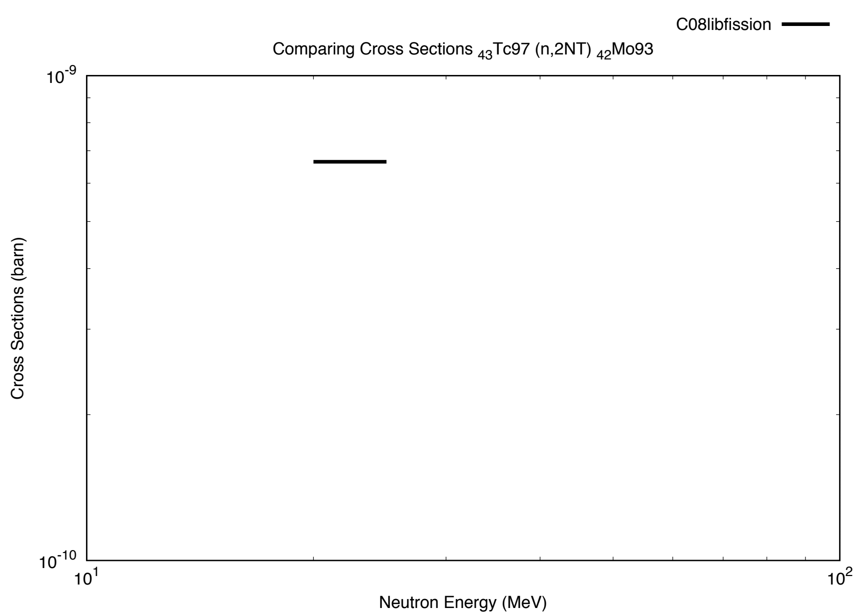
Table 3. List of 37 reaction cross sections in the current CINDER2008 fission-weighted library but not in the updated CINDER2008 fission-weighted library.

Target Nucl.	Reactions	Product Nucl.	Target Nucl.	Reactions	Product Nucl.
*30Zn62	(n,2N)	30Zn61m1	*83Bi203	(n,NA)	81Tl199m1
*30Zn62	(n,2N)	30Zn61m2	*83Bi203	(n,N3HE A PT)	81Tl200m1
*30Zn62	(n,2N)	30Zn61m3	*83Bi203	(n,N2P 3HE PD)	81Tl201m1
*52Te129	(n,2N)	52Te128m1	*84Po206	(n,TA)	81Tl200m1
*56Ba129	(n,ND 2NP T)	55Cs127m1	*84Po206	(n,NPA DA)	81Tl201m1
*56Ba129	(n,G)	56Ba130m1	*84Po206	(n,2N)	84Po205m1
*58Ce134	(n,NA)	56Ba130m1	*84Po206	(n,2N)	84Po205m2
*58Ce134	(n,3N)	58Ce132m1	*85At211	(n,2A)	81Tl204m1
*58Ce137	(n,2N)	58Ce136m1	*85At211	(n,2NA)	83Bi206m1
*58Ce137	(n,G)	58Ce138m1	*85At211	(n,NA)	83Bi207m1
*61Pm143	(n,NPA DA)	58Ce138m1	†28Ni57	(n,2NA)	26Fe52m1
*61Pm143	(n,NT)	60Nd140m1	†43Tc97	(n,2NT)	42Mo93
*61Pm143	(n,2N)	61Pm142m1	†43Tc97m1	(n,2NT)	42Mo93

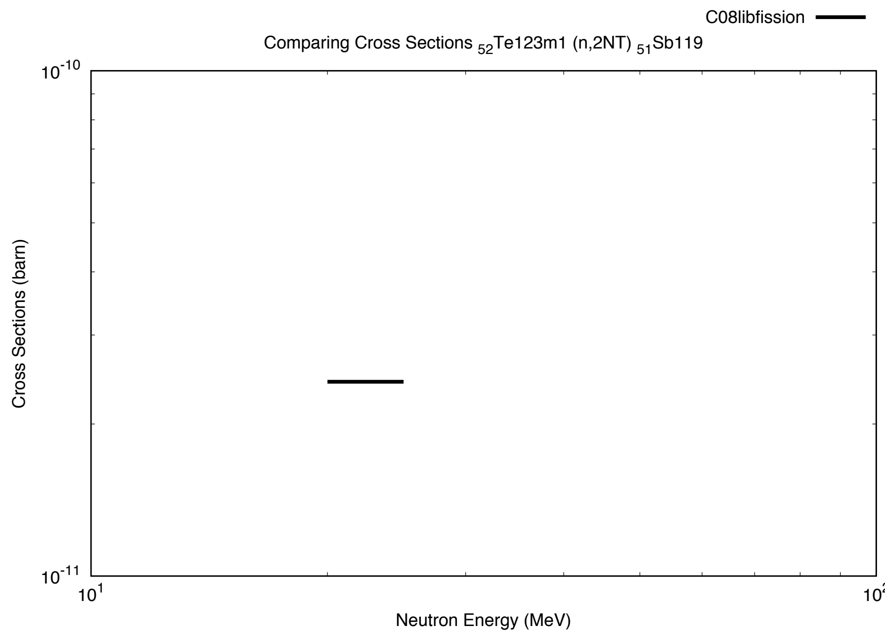
*65Tb152	(n,NA)	63Eu148m1	†52Te123m1	(n,2NT)	51Sb119
*65Tb152	(n,G)	65Tb153m1	‡73Ta180	(n,3N)	73Ta178m1
*74W181	(n,2N)	74W180m1	‡74W181	(n,2ND NT 3NP)	73Ta178m1
*79Au198	(n,G)	79Au199m1	‡82Pb202	(n,G)	82Pb203m1
*82Pb202	(n,G)	82Pb203m2	‡83Bi203	(n,2NA)	81Tl198m1
*83Bi203	(n,2NA)	81Tl198m2			



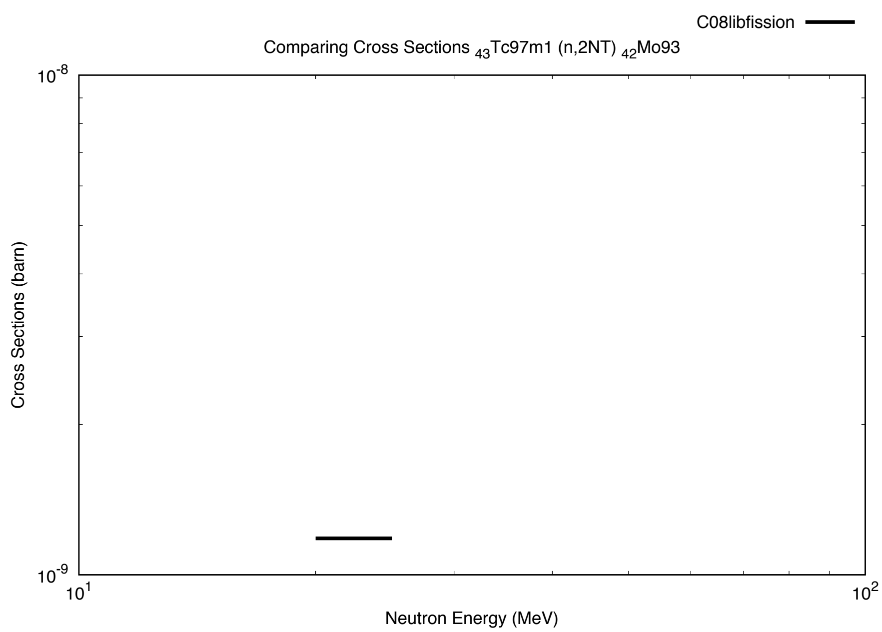
(a)



(b)



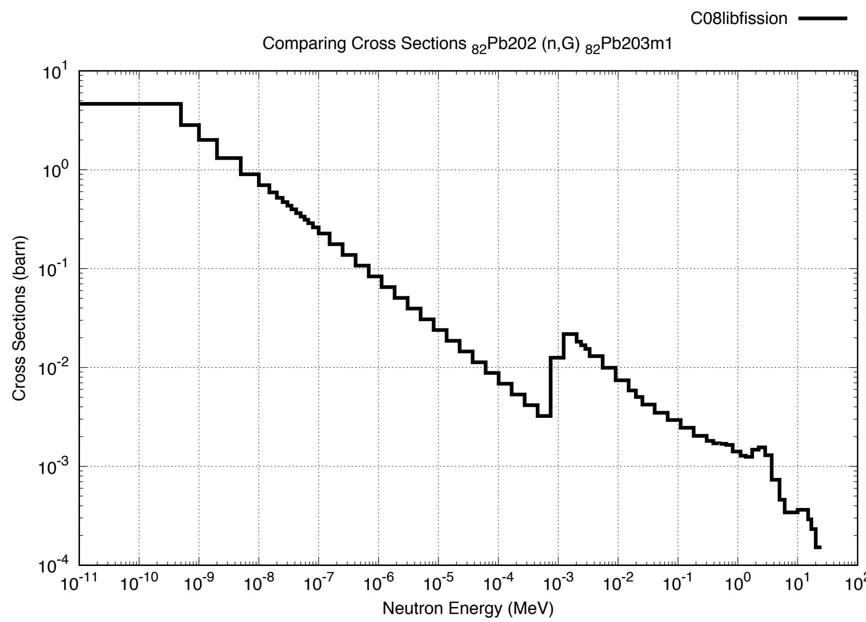
(c)



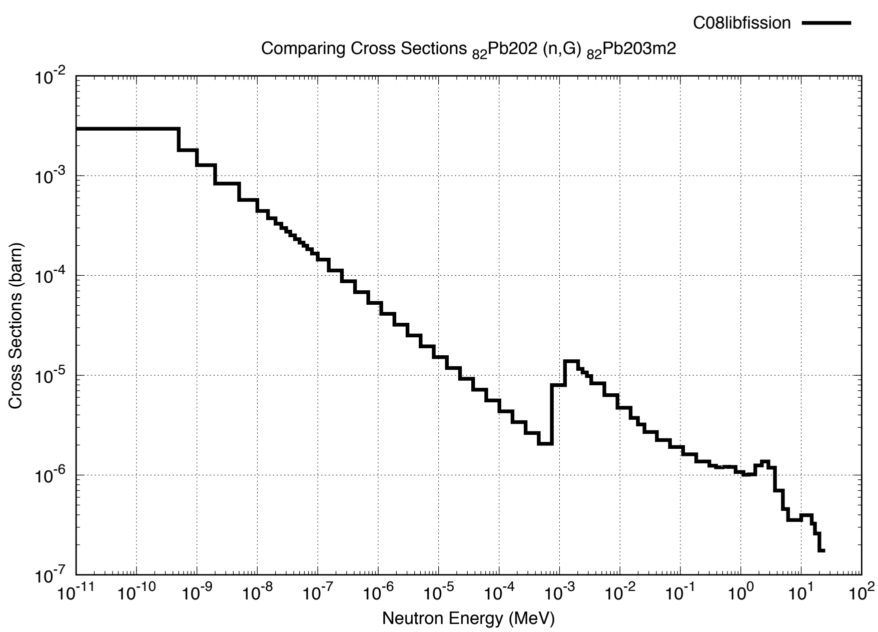
(d)

Figure 2. Four reaction cross sections in EAF-2010 (as of July 22, 2016) with their threshold energy higher than the upper limit energy bin of the group structure in the updated CINDER2008 fission-weighted library.

The remaining four reactions, marked (‡) in Table 3, are also presented in EAF-2010, but they are not shown in the updated fission-weighted library due to the treatment of the incomplete isomers in the CINDER2008 library maker tool. One such example as shown in Fig. 3 is *82Pb202 (n,G) 82Pb203m1*, whose product Pb203 has three isomers, one ground state and two metastable states. In the current CINDER2008 fission-weighted library, production cross sections of all three isomers are presented for the (n, G) reaction of Pb202. However, in EAF-2010 the production cross sections of Pb203m2 is now not included resulting in an incomplete list of production cross sections for Pb203. In dealing with such a situation, the CINDER2008 library maker tool sums the production cross sections of Pb203 and Pb203m1 and groups it under Pb203. As observed in Fig. 3(c), the *82Pb202 (n,G) 82Pb203* reaction cross sections in the updated library (red line) is slightly higher than those in the current one (black line).



(a)



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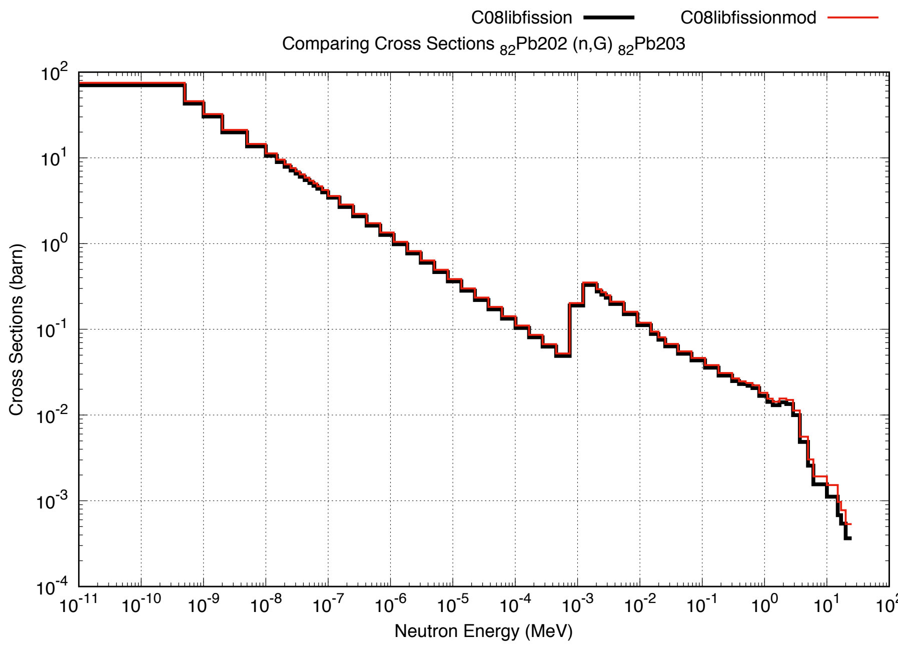


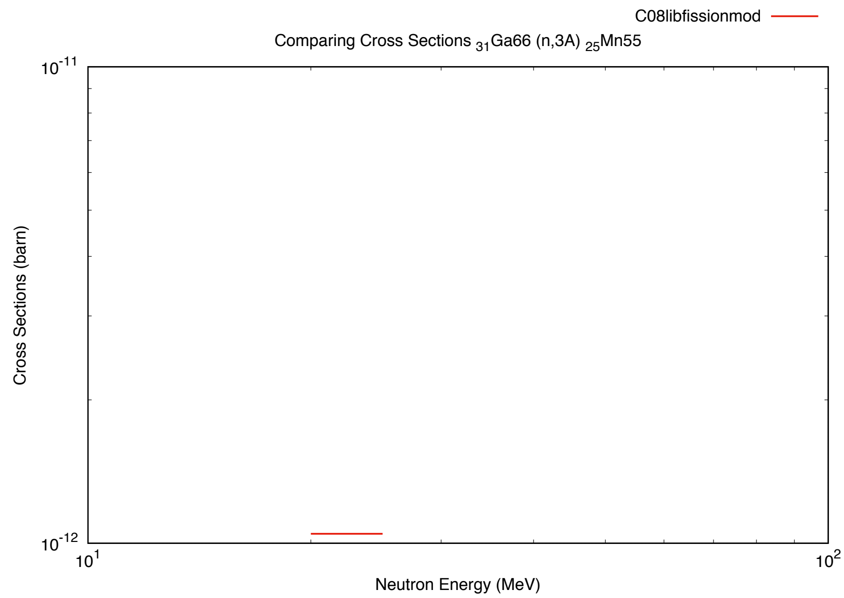
(c)

Figure 3. Production cross sections of Pb203 and its isomers through (n, G) reaction in the current and updated CINDER2008 fission-weighted library.

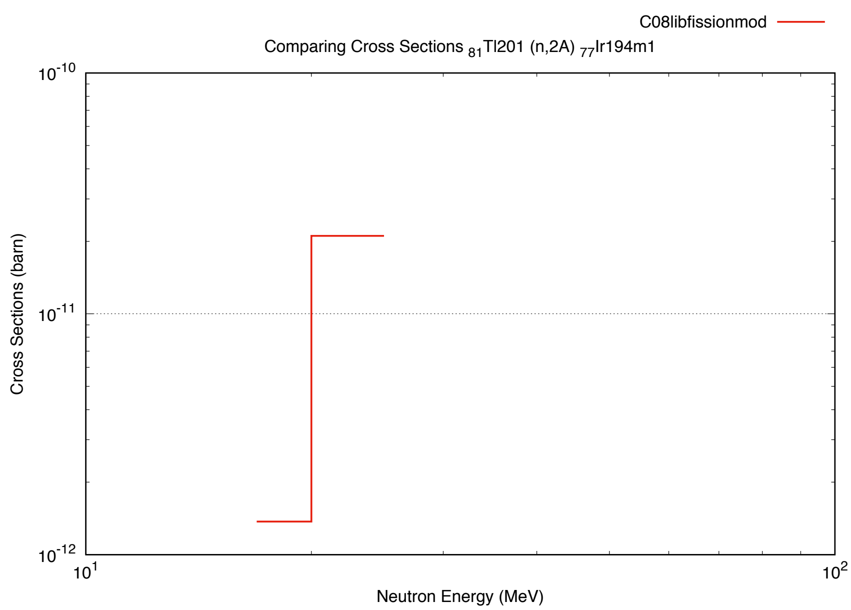
There are 14 reaction cross sections, listed in Table 4, presented in the updated CINDER2008 fission-weighted library but not in the current one. As illustrated in Fig. 4 for some of the list, these reactions all have cross sections barely above the library maker tool's cut-off of 1E-12 barns, and only in the highest one or two energy groups.

Table 4. List of fourteen reaction cross sections not present in the current CINDER2008 fission-weighted library but present in the updated CINDER2008 fission-weighted library.

Target Nucl.	**Reactions**	**Product Nucl.**
31Ga66	(n,3A)	25Mn55
47Ag108m1	(n,3NA)	45Rh102m1
54Xe131m1	(n,3NA)	52Te125m1
60Nd140	(n,3NA)	58Ce134
64Gd147	(n,P3HE)	61Pm144
67Ho163	(n,2NT)	66Dy159
69Tm173	(n,2P)	67Ho172
78Pt195	(n,2NT)	77Ir191
79Au196	(n,NPA)	76Os191m1
81Tl201	(n,2A)	77Ir194m1
81Tl201	(n,2A)	77Ir194m2
82Pb201	(n,NPA)	79Au196m1
82Pb201	(n,NPA)	79Au196m2
83Bi210m1	(n,4NA)	81Tl203



(a)

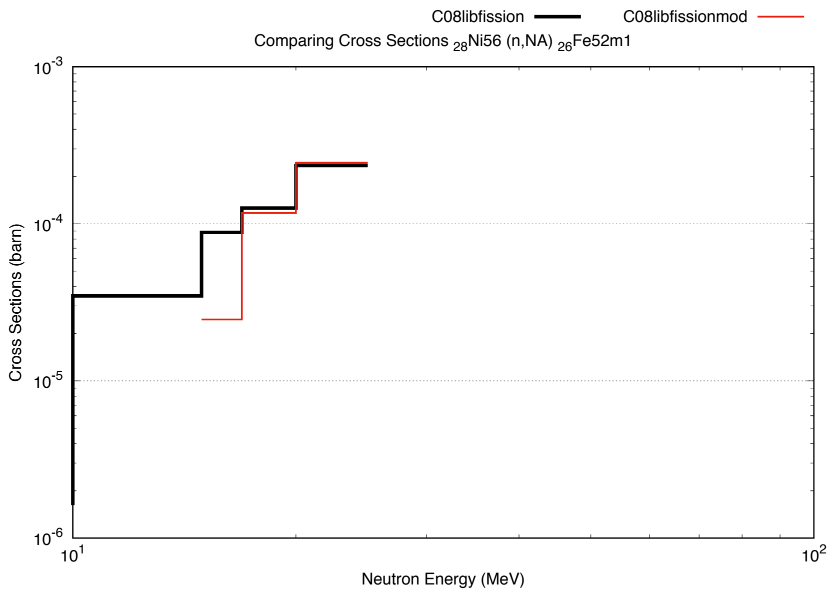


(b)

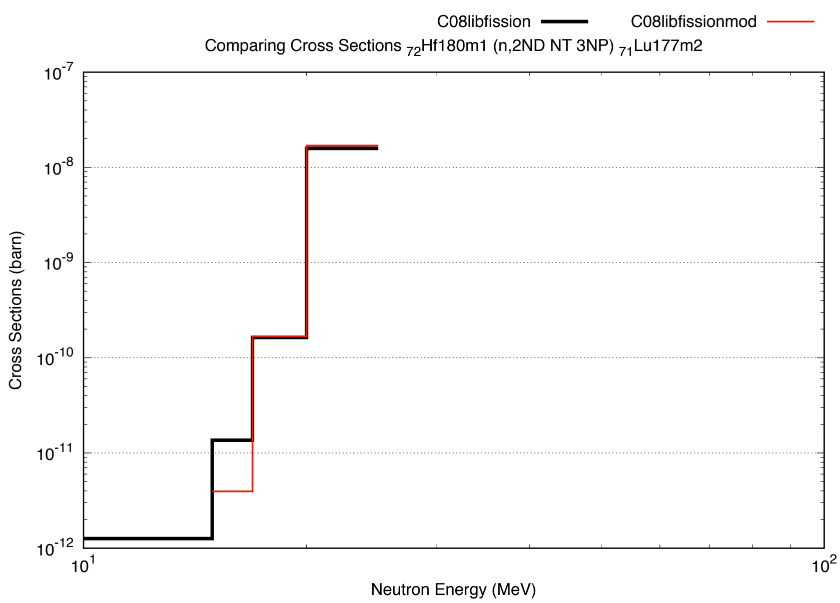
Figure 4. Two examples of reaction cross sections appearing in the updated CINDER2008 fission-weighted library but not present in the current CINDER2008 fission-weighted library.

The majority of ~17,000 reaction cross sections in both versions of the CINDER2008 fission-weighted library are consistent with each other. There are nevertheless 151 reactions whose cross sections show significant difference (significant difference in this report is defined as ratios of cross sections in one or more energy groups are greater than 2) between the two versions. But most of them as illustrated in Fig. 5 just have one or two energy groups with more than a factor of 2 in difference while the cross sections in the rest of the spectrum are in line with each other. However, for the reactions listed in Table 5, where all of the products are in metastable states, the difference involves most of the energy groups. The comparison of those 6 reaction cross sections are plotted in Fig. 6 for the current and updated

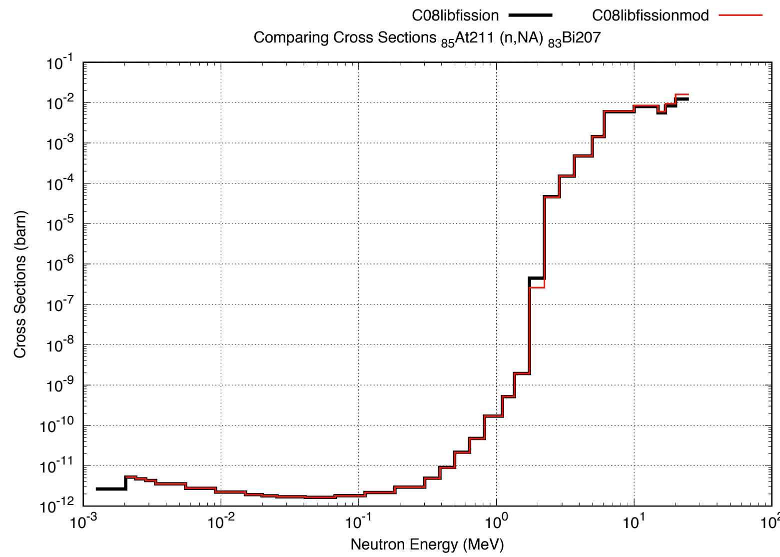
CINDER2008 fission-weighted library. Such a big difference is probably due to the revision of the branching ratios for the metastable states in EAF-2010.



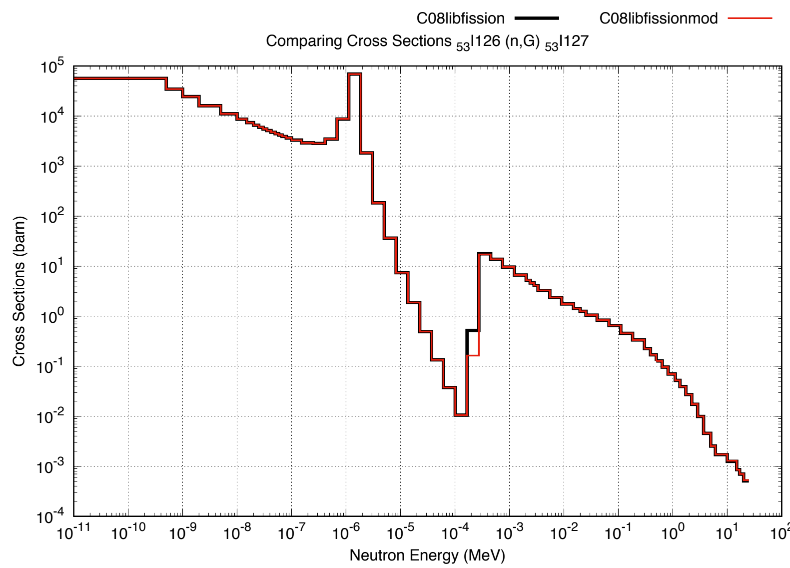
(a)



(b)


C08libfission
C08libfissionmod
Comparing Cross Sections $_{85}$At211 (n,NA) $_{83}$Bi207
Cross Sections (barn)
Neutron Energy (MeV)

(c)


C08libfission
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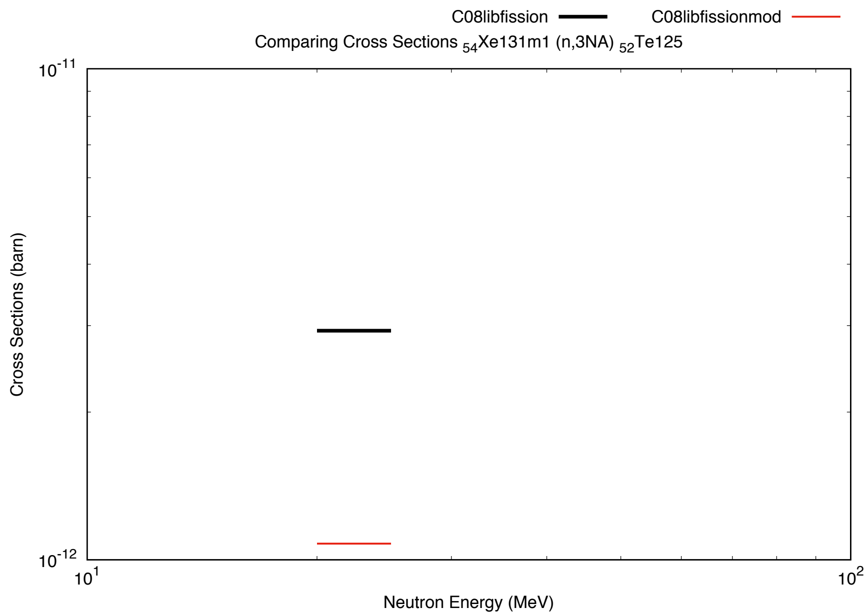
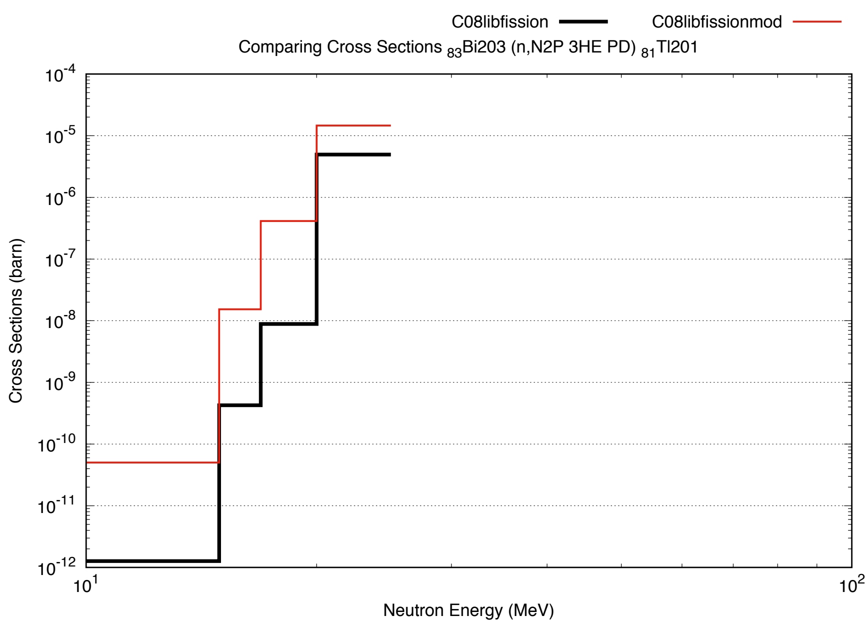
Comparing Cross Sections $_{53}$I126 (n,G) $_{53}$I127
Cross Sections (barn)
Neutron Energy (MeV)

(d)



(e)

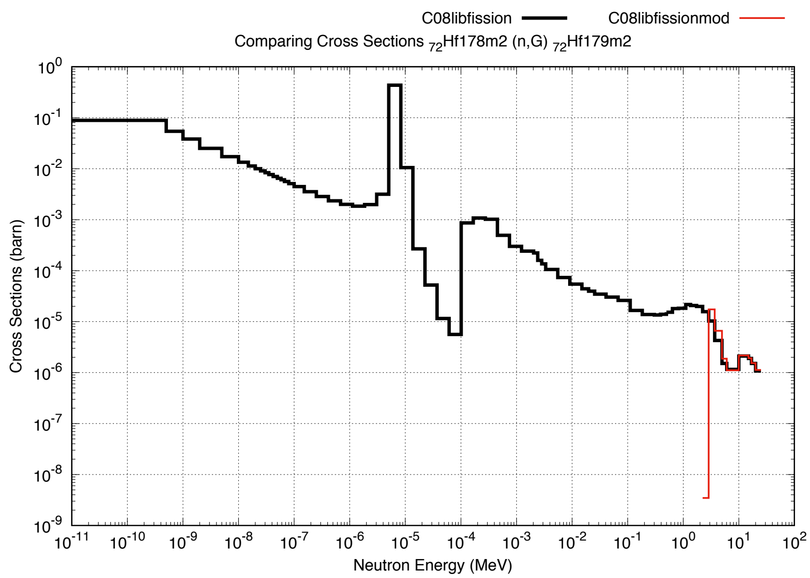


(f)

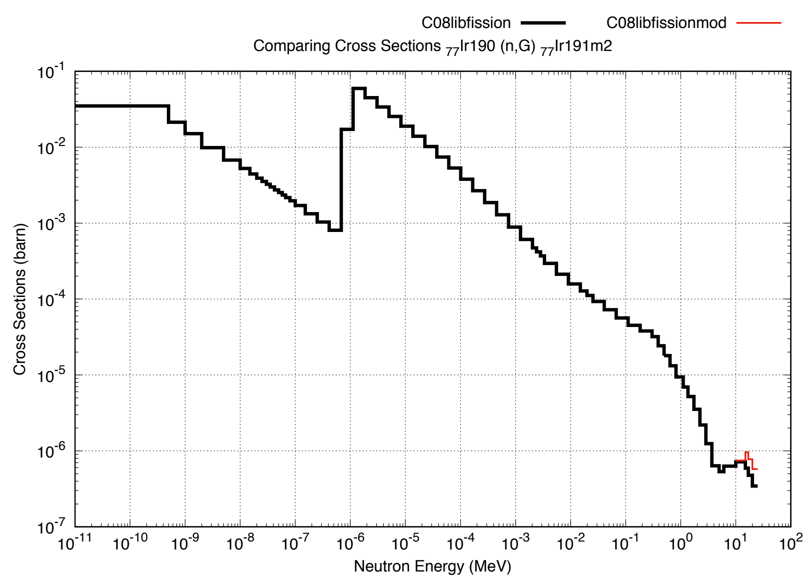
Figure 5. Examples of reaction cross sections showing significant differences between the current and updated CINDER2008 fission-weighted library, but that are not of serious concern.

Table 5. List of six reaction cross sections with significant difference between the current and updated CINDER2008 fission libraries which are of serious concern.

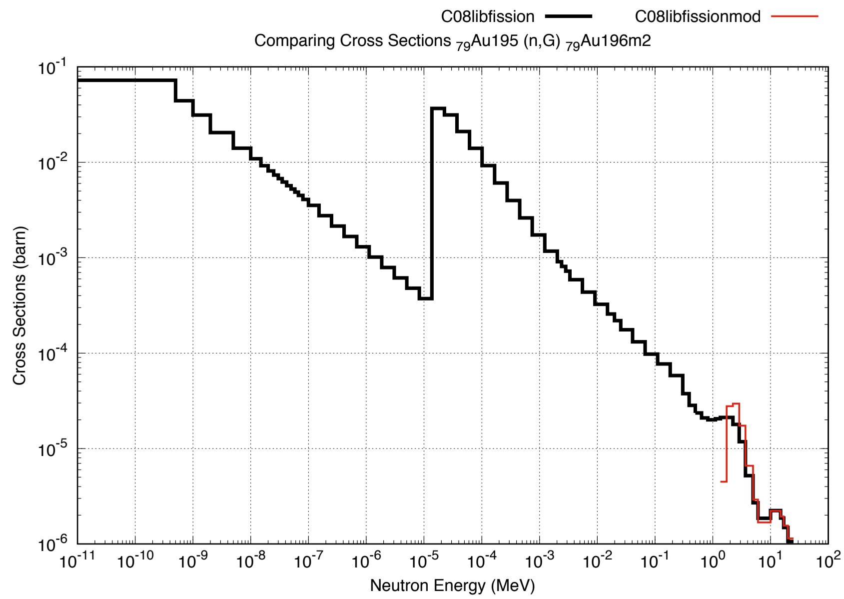
Target Nucl.	Reactions	Product Nucl.
72Hf178m2	(n,G)	72Hf179m2
77Ir190	(n,G)	77Ir191m2
79Au195	(n,G)	79Au196m2
81Tl205	(n,G)	81Tl206m1
78Pt196	(n,G)	78Pt197m1
79Au199	(n,G)	79Au200m1

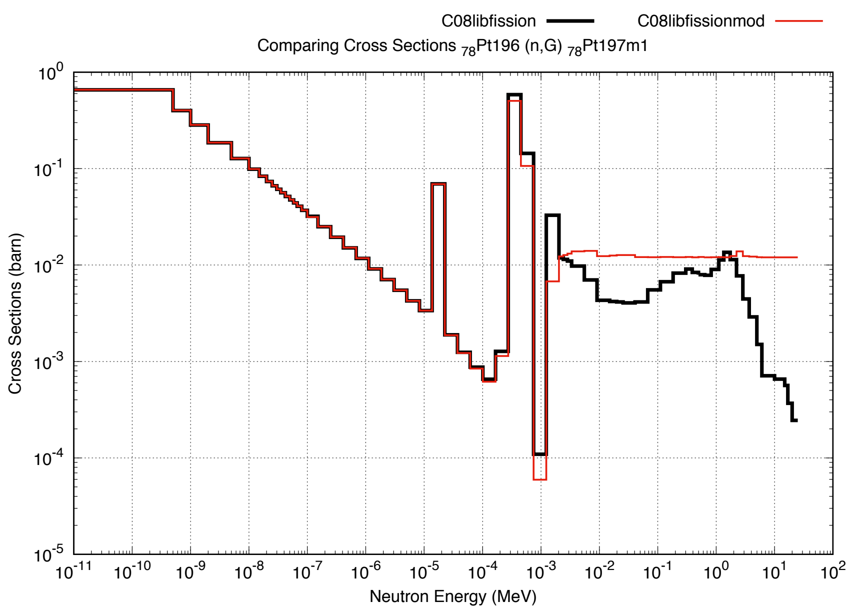


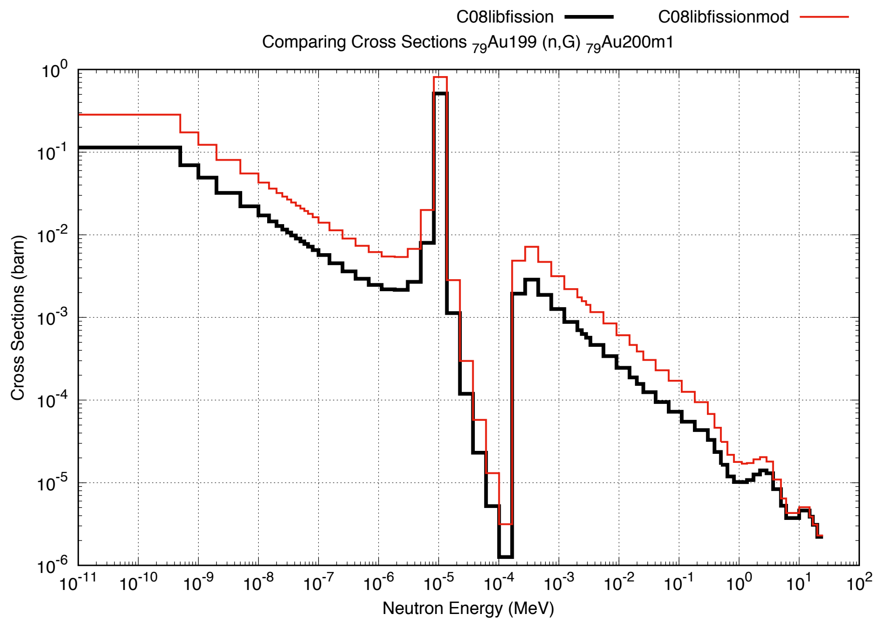
(a)



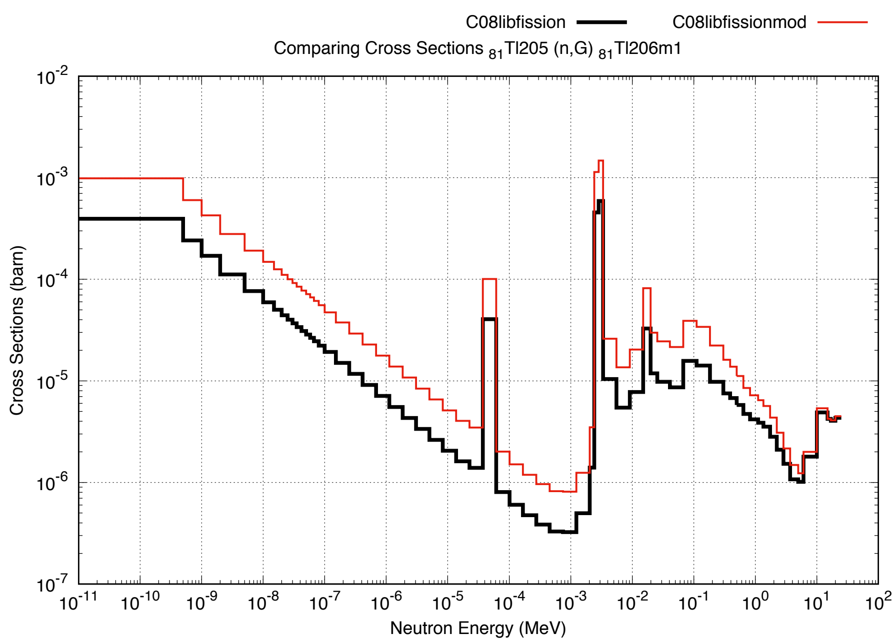
(b)


C08libfission
C08libfissionmod
Comparing Cross Sections $_{79}$Au195 (n,G) $_{79}$Au196m2
Cross Sections (barn)
Neutron Energy (MeV)
(c)


C08libfission
C08libfissionmod
Comparing Cross Sections $_{78}$Pt196 (n,G) $_{78}$Pt197m1
Cross Sections (barn)
Neutron Energy (MeV)
(d)



(e)



(f)

Figure 6. Six reaction cross sections showing significant difference between the current and updated CINDER2008 fission-weighted library which are of serious concern.

3.2 FLAT-WEIGHTED LIBRARY

The flat cross section library in CINDER2008 has the same energy range as the fission library but it has a fine 321-group energy structure compared to fission's 66-group structure. As discussed above, the current flat-weighted library in CINDER2008 contains a considerable fraction of truncated cross sections sourced from EAF-2010 and needs to be updated. The results of the updated flat-weighted library are checked against the current one and are discussed below.

There are 37 reaction cross sections, as listed in Table 6, missing in the updated CINDER2008 flat-weighted library though they are present in the current one. The list is very similar to that in Table 3, so is the discussion for reactions marked (*), (†) and (‡). One exception is reaction Tl204 (n, 2A) Ir197m1 marked (**). This reaction cross section is included in EAF-2010, but as shown in Fig. 7 the single-group cross section of this reaction is insignificant and is very close to 1E-12 barn, which is the inherently imposed cross section cut-off limit in the library maker tool of CINDER2008. The presence or disappearance of this reaction is probably due to the treatment of the CINDER2008 library maker tool.

Table 6. List of 37 reaction cross sections in the current CINDER2008 flat-weighted library but not in the updated CINDER2008 flat-weighted library.

Target Nucl.	**Reactions**	**Product Nucl.**	**Target Nucl.**	**Reactions**	**Product Nucl.**
*30Zn62	(n,2N)	30Zn61m1	*83Bi203	(n,NA)	81Tl199m1
*30Zn62	(n,2N)	30Zn61m2	*83Bi203	(n,N3HE A PT)	81Tl200m1
*30Zn62	(n,2N)	30Zn61m3	*83Bi203	(n,N2P 3HE PD)	81Tl201m1
*52Te129	(n,2N)	52Te128m1	*84Po206	(n,NPA DA)	81Tl201m1
*56Ba129	(n,ND 2NP T)	55Cs127m1	*84Po206	(n,2N)	84Po205m1
*56Ba129	(n,G)	56Ba130m1	*84Po206	(n,2N)	84Po205m2
*58Ce134	(n,NA)	56Ba130m1	*85At211	(n,2A)	81Tl204m1
*58Ce134	(n,3N)	58Ce132m1	*85At211	(n,2NA)	83Bi206m1
*58Ce137	(n,2N)	58Ce136m1	*85At211	(n,NA)	83Bi207m1
*58Ce137	(n,G)	58Ce138m1	†28Ni57	(n,2NA)	26Fe52m1
*61Pm143	(n,NPA DA)	58Ce138m1	†43Tc97	(n,2NT)	42Mo93
*61Pm143	(n,NT)	60Nd140m1	†43Tc97m1	(n,2NT)	42Mo93
*61Pm143	(n,2N)	61Pm142m1	†52Te123m1	(n,2NT)	51Sb119
*65Tb152	(n,NA)	63Eu148m1	‡73Ta180	(n,3N)	73Ta178m1
*65Tb152	(n,G)	65Tb153m1	‡74W181	(n,2ND NT 3NP)	73Ta178m1
*74W181	(n,2N)	74W180m1	‡82Pb202	(n,G)	82Pb203m1
*79Au198	(n,G)	79Au199m1	‡83Bi203	(n,2NA)	81Tl198m1
*82Pb202	(n,G)	82Pb203m2	**81Tl204	(n, 2A)	77Ir197m1
*83Bi203	(n,2NA)	81Tl198m2			

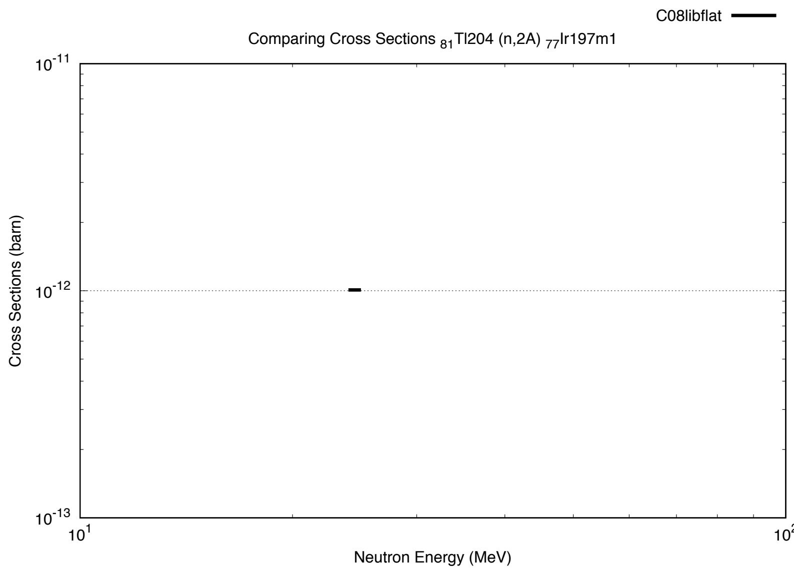


Figure 7. Reaction cross sections shown in the current CINDER2008 flat-weighted library but not in the updated one due to the cut-off treatment of the CINDER2008 library maker tool.

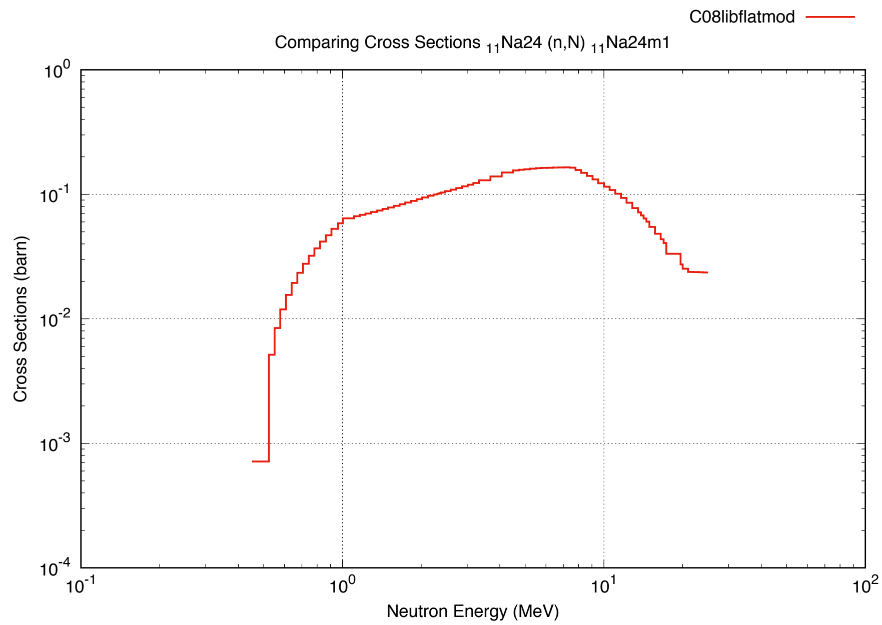
There are 170 reaction cross section in the updated CINDER2008 flat-weighted library that are not in the current CINDER2008 flat-weighted library. 167 of them as listed in Table 7 are actually significant and present in the current CINDER2008 fission-weighted library, which means they are accidentally missed in the current flat-weighted library during the cross section processing and are fixed by this update. Some of those cross sections are shown in Fig. 8. The remaining 3 reactions, whose cross sections are shown in Fig. 9, contains a few energy groups with insignificant cross sections slightly above the 1E-12 barn cut-off limit of the CINDER2008 library maker tool. As discussed above, they are probably due to the treatment of grouping in NJOY and treatment of the library maker tool in CINDER2008 and are not of concern. The same reason could be applied for those 14 reaction cross sections in Table 4 that appear in the updated fission-weighted library but not in the current fission-weighted library. They are all present in both the current and updated flat-weighted library.

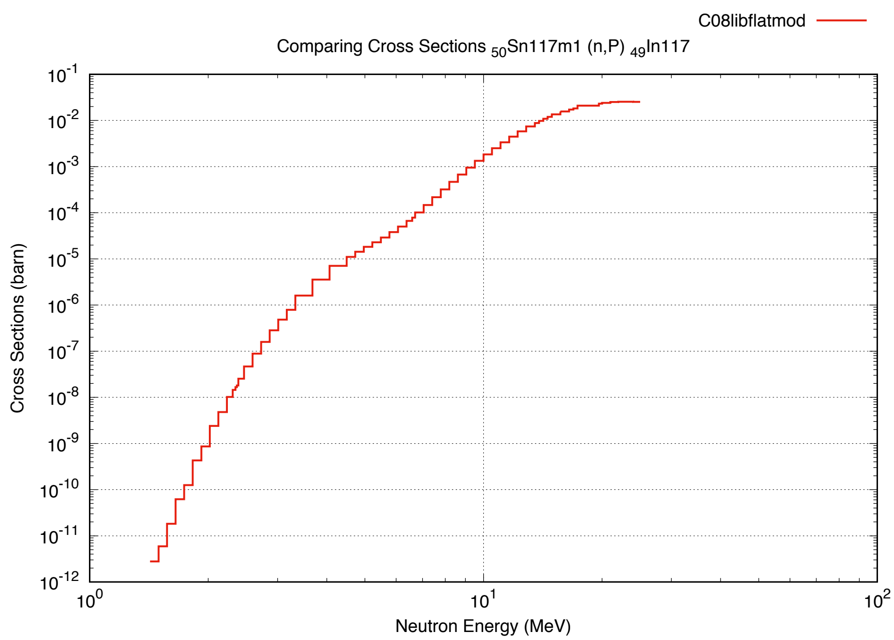
Table 7. List of 167 reaction cross sections missing in the current CINDER2008 flat-weighted library but present in the updated CINDER2008 flat-weighted library.

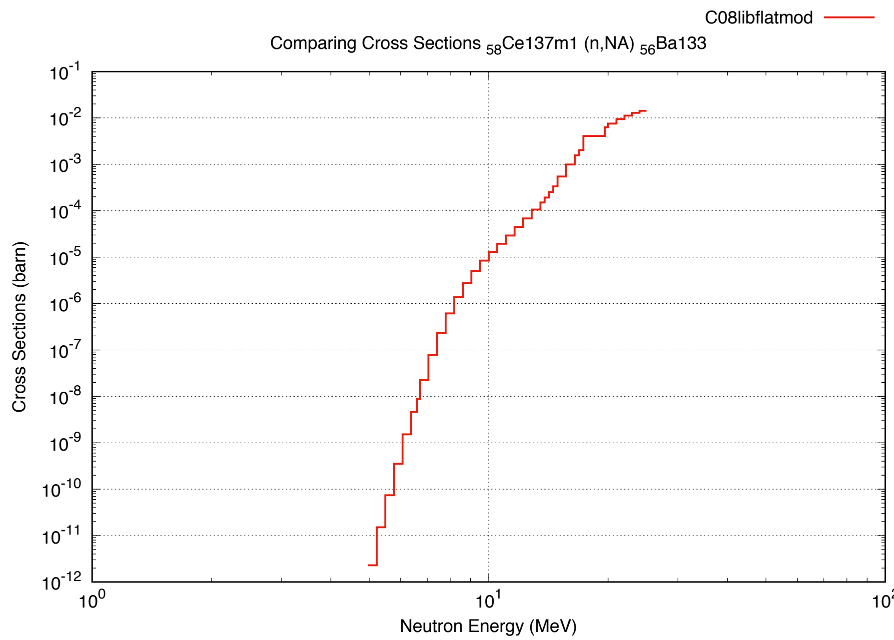
Target Nucl.	Reactions	Product Nucl.	Target Nucl.	Reactions	Product Nucl.
11Na24	(n,N)	11Na24m1	64Gd147	(n,3HEA)	60Nd141m1
13Al26	(n,N)	13Al26m1	64Gd147	(n,2P)	62Sm146
25Mn52	(n,N)	25Mn52m1	64Gd150	(n,P)	63Eu150
30Zn62	(n,2A)	26Fe55	64Gd150	(n,P)	63Eu150m1
33As77	(n,A)	31Ga74m1	64Gd159	(n,NA)	62Sm155
34Se73	(n,3A)	28Ni62	65Tb152	(n,2N2A)	61Pm143
34Se73	(n,PA)	31Ga69	65Tb152	(n,N)	65Tb152m1
36Kr81	(n,N)	36Kr81m1	65Tb154	(n,N)	65Tb154m1
37Rb82m1	(n,PA)	34Se78	65Tb154	(n,N)	65Tb154m2
37Rb84	(n,N)	37Rb84m1	65Tb158	(n,N2A)	61Pm150
38Sr82	(n,2A)	34Se75	65Tb161	(n,NA)	63Eu157

Target Nucl.	Reactions	Product Nucl.	Target Nucl.	Reactions	Product Nucl.
38Sr83	(n,N)	38Sr83m1	66Dy153	(n,2P)	64Gd152
38Sr85	(n,2A)	34Se78	66Dy165	(n,NA)	64Gd161
38Sr85	(n,N)	38Sr85m1	66Dy166	(n,NA)	64Gd162
39Y86	(n,2A)	35Br79m1	67Ho163	(n,N)	67Ho163m1
39Y86	(n,PA)	36Kr82	68Er171	(n,NA)	66Dy167
39Y86	(n,N)	39Y86m1	68Er172	(n,NA)	66Dy168
39Y87	(n,N)	39Y87m1	69Tm171	(n,P)	68Er171
40Zr86	(n,2A)	36Kr79m1	71Lu177	(n,P)	70Yb177
40Zr89	(n,N)	40Zr89m1	71Lu177	(n,P)	70Yb177m1
41Nb90	(n,2A)	37Rb83	73Ta177	(n,P)	72Hf177m1
41Nb90	(n,N)	41Nb90m2	73Ta177	(n,P)	72Hf177m2
41Nb92m1	(n,2A)	37Rb85	73Ta179	(n,P)	72Hf179m1
41Nb95m1	(n,2A)	37Rb88	73Ta179	(n,P)	72Hf179m2
41Nb96	(n,2A)	37Rb89	73Ta184	(n,P)	72Hf184
42Mo93	(n,PA)	39Y89m1	73Ta184	(n,P)	72Hf184m1
43Tc98	(n,PA)	40Zr94	74W181	(n,NA)	72Hf177m2
43Tc99m1	(n,P)	42Mo99	74W185	(n,N)	74W185m1
44Ru97	(n,PA)	41Nb93	74W188	(n,NA)	72Hf184m1
44Ru97	(n,PA)	41Nb93m1	75Re184	(n,N)	75Re184m1
45Rh102	(n,PA)	42Mo98	76Os183	(n,2N2A)	72Hf174
45Rh102m1	(n,PA)	42Mo98	76Os183m1	(n,2N2A)	72Hf174
46Pd109	(n,N)	46Pd109m1	76Os193	(n,NA)	74W189
47Ag105	(n,PA)	44Ru101	77Ir186	(n,2N2A)	73Ta177
48Cd107	(n,PA)	45Rh103	77Ir188	(n,2N2A)	73Ta179
48Cd107	(n,PA)	45Rh103m1	77Ir192	(n,P)	76Os192m1
48Cd115	(n,N)	48Cd115m1	77Ir193m1	(n,P)	76Os193
49In111	(n,N)	49In111m1	77Ir194	(n,N)	77Ir194m2
50Sn117m1	(n,P)	49In117	78Pt191	(n,2N2A)	74W182
50Sn117m1	(n,P)	49In117m1	78Pt191	(n,P)	77Ir191m1
51Sb127	(n,A)	49In124	78Pt191	(n,P)	77Ir191m2
51Sb127	(n,A)	49In124m1	78Pt192	(n,P)	77Ir192
51Sb128	(n,P)	50Sn128m1	78Pt192	(n,P)	77Ir192m1
52Te119	(n,N)	52Te119m1	78Pt192	(n,P)	77Ir192m2
52Te121	(n,NA)	50Sn117	78Pt194	(n,NA)	76Os190m1
52Te121	(n,NA)	50Sn117m1	78Pt195	(n,P)	77Ir195
52Te121	(n,N)	52Te121m1	78Pt195	(n,P)	77Ir195m1
52Te121m1	(n,NA)	50Sn117	78Pt195	(n,N)	78Pt195m1
52Te121m1	(n,NA)	50Sn117m1	78Pt195m1	(n,P)	77Ir195m1
52Te127	(n,P)	51Sb127	78Pt197	(n,N)	78Pt197m1
53I123	(n,NA)	51Sb119	78Pt200	(n,NA)	76Os196
53I123	(n,NA)	51Sb119m1	78Pt202	(n,NA)	76Os198

Target Nucl.	Reactions	Product Nucl.	Target Nucl.	Reactions	Product Nucl.
54Xe125	(n,N)	54Xe125m1	79Au193	(n,N)	79Au193m1
54Xe127	(n,PA)	51Sb123	79Au194	(n,N)	79Au194m2
54Xe127	(n,N)	54Xe127m1	79Au195	(n,NA)	77Ir191m1
54Xe133m1	(n,P)	53I133	79Au195	(n,NA)	77Ir191m2
54Xe133m1	(n,P)	53I133m1	79Au195	(n,N)	79Au195m1
55Cs127	(n,NA)	53I123	79Au199	(n,P)	78Pt199m1
55Cs129	(n,PA)	52Te125m1	80Hg195	(n,N)	80Hg195m1
56Ba128	(n,N2A)	52Te120	80Hg195m1	(n,2N2A)	76Os186
56Ba128	(n,NA)	54Xe124	80Hg197	(n,N)	80Hg197m1
56Ba129	(n,NA)	54Xe125	80Hg203	(n,NA)	78Pt199
56Ba129	(n,NA)	54Xe125m1	80Hg203	(n,NA)	78Pt199m1
56Ba131	(n,NA)	54Xe127m1	81Tl203	(n,PA)	78Pt199m1
56Ba131	(n,N)	56Ba131m1	81Tl204	(n,NA)	79Au200m1
56Ba133m1	(n,PA)	53I129	81Tl205	(n,P)	80Hg205
56Ba135m1	(n,P)	55Cs135m1	82Pb203	(n,N)	82Pb203m1
56Ba139	(n,NA)	54Xe135m1	82Pb203	(n,N)	82Pb203m2
58Ce134	(n,N2A)	54Xe126	83Bi205	(n,TA)	80Hg199m1
58Ce135	(n,NA)	56Ba131	83Bi208	(n,TA)	80Hg202
58Ce135	(n,NA)	56Ba131m1	83Bi210	(n,N)	83Bi210m1
58Ce135	(n,N)	58Ce135m1	84Po206	(n,2P)	82Pb205
58Ce137m1	(n,NA)	56Ba133	84Po206	(n,2P)	82Pb205m1
58Ce137m1	(n,NA)	56Ba133m1	84Po210	(n,P)	83Bi210
60Nd140	(n,N2A)	56Ba132	84Po210	(n,P)	83Bi210m1
60Nd140	(n,NA)	58Ce136	85At210	(n,2P)	83Bi209
60Nd141	(n,NA)	58Ce137m1	88Ra228	(n,3N2A)	84Po218
60Nd141	(n,N)	60Nd141m1	88Ra228	(n,TA)	85At222
61Pm143	(n,NA)	59Pr139	89Ac228	(n,3N2A)	85At218
61Pm144	(n,N2A)	57La136	91Pa234	(n,2NA)	89Ac229
61Pm144	(n,N2A)	57La136m1	93Np236m1	(n,2NA)	91Pa231
62Sm146	(n,P)	61Pm146	94Pu234	(n,3N2A)	90Th224
63Eu147	(n,3HEA)	59Pr141	94Pu247	(n,2NA)	92U242
64Gd146	(n,3HEA)	60Nd140			

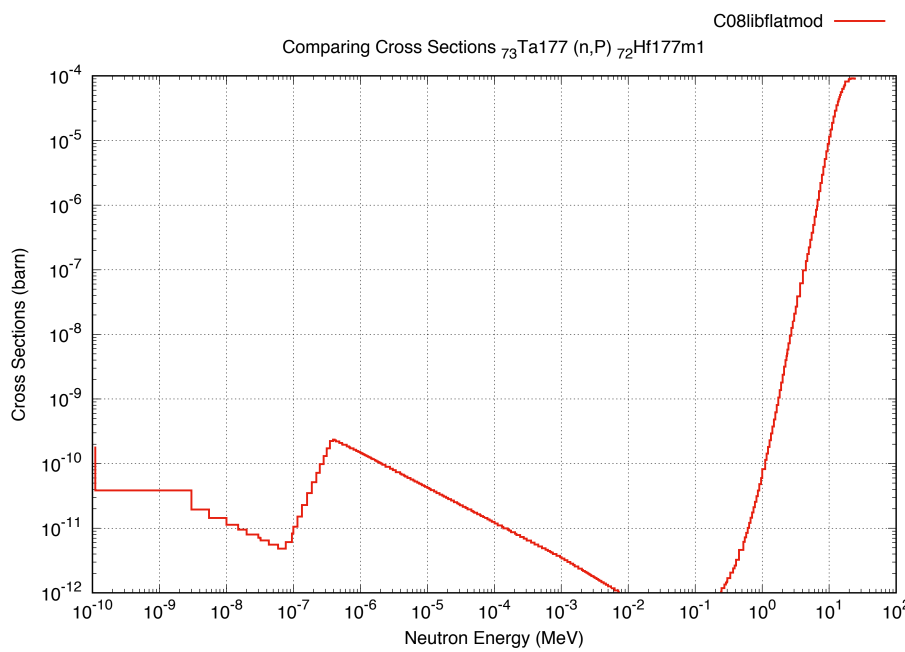

C08libflatmod
Comparing Cross Sections $_{11}$Na24 (n,N) $_{11}$Na24m1
Cross Sections (barn)
Neutron Energy (MeV)
10^{0}
10^{-1}
10^{-2}
10^{-3}
10^{-4}
10^{-1}
10^{0}
10^{1}
10^{2}
(a)


C08libflatmod
Comparing Cross Sections $_{50}$Sn117m1 (n,P) $_{49}$In117
Cross Sections (barn)
Neutron Energy (MeV)
10^{-1}
10^{-2}
10^{-3}
10^{-4}
10^{-5}
10^{-6}
10^{-7}
10^{-8}
10^{-9}
10^{-10}
10^{-11}
10^{-12}
10^{0}
10^{1}
10^{2}
(b)



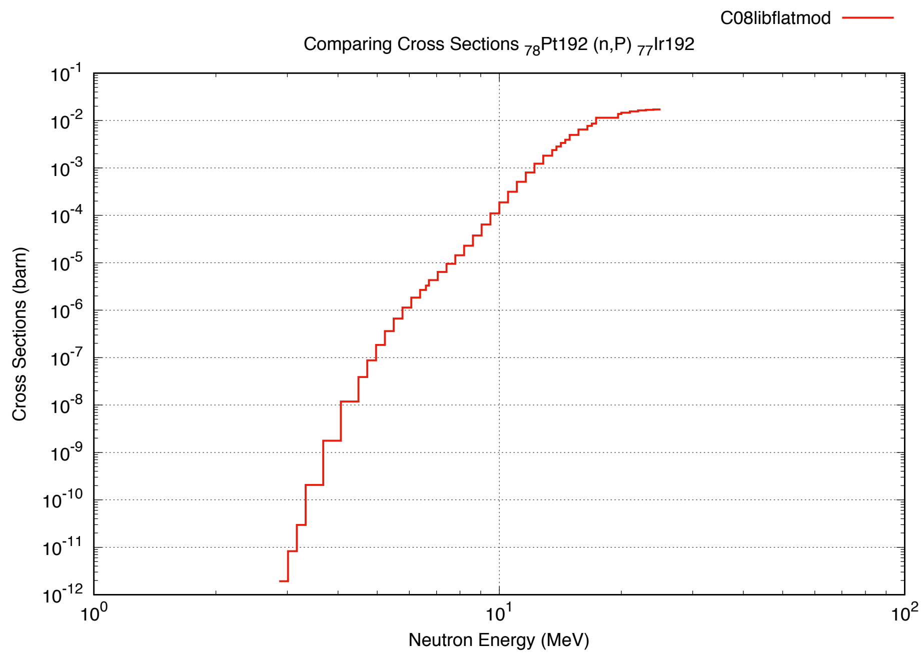
C08libflatmod
Comparing Cross Sections $_{58}$Ce137m1 (n,NA) $_{56}$Ba133
Cross Sections (barn)
Neutron Energy (MeV)

(c)

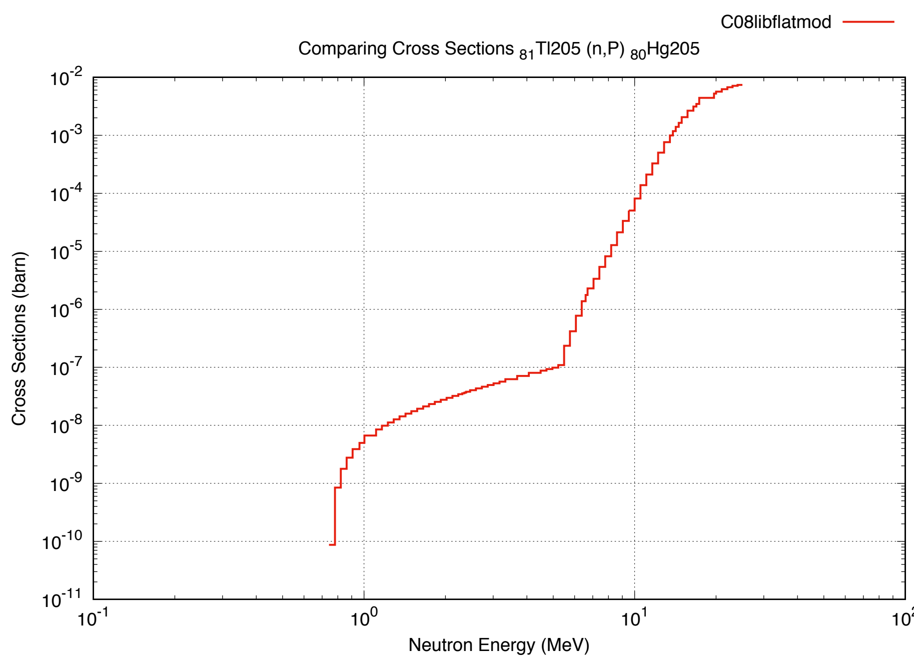


C08libflatmod
Comparing Cross Sections $_{73}$Ta177 (n,P) $_{72}$Hf177m1
Cross Sections (barn)
Neutron Energy (MeV)

(d)

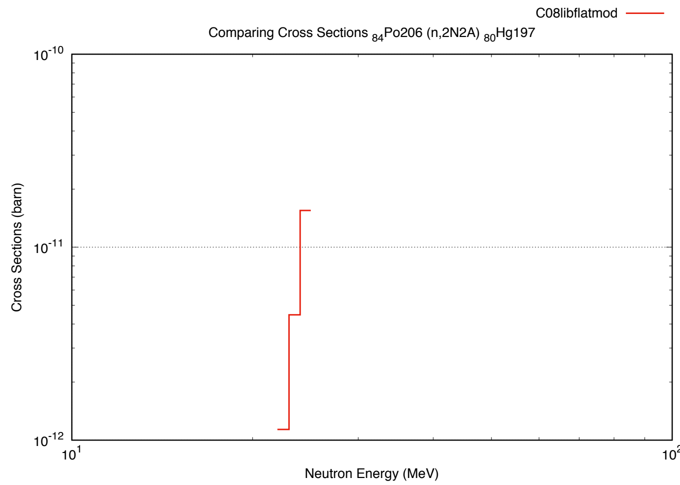


(e)

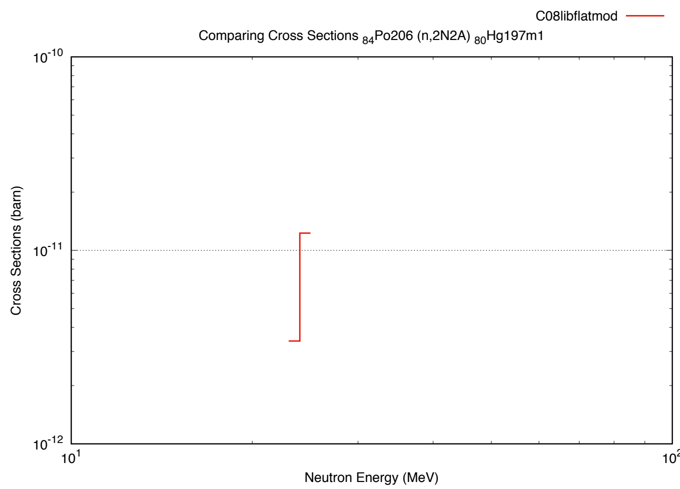


(f)

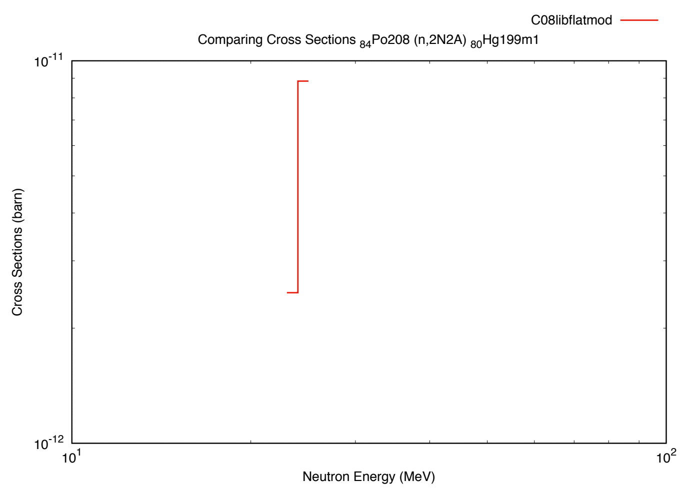
Figure 8. Examples of reaction cross sections wrongly missing in the current CINDER2008 flat-weighted library but present in updated CINDER2008 flat-weighted library.



(a)



(b)

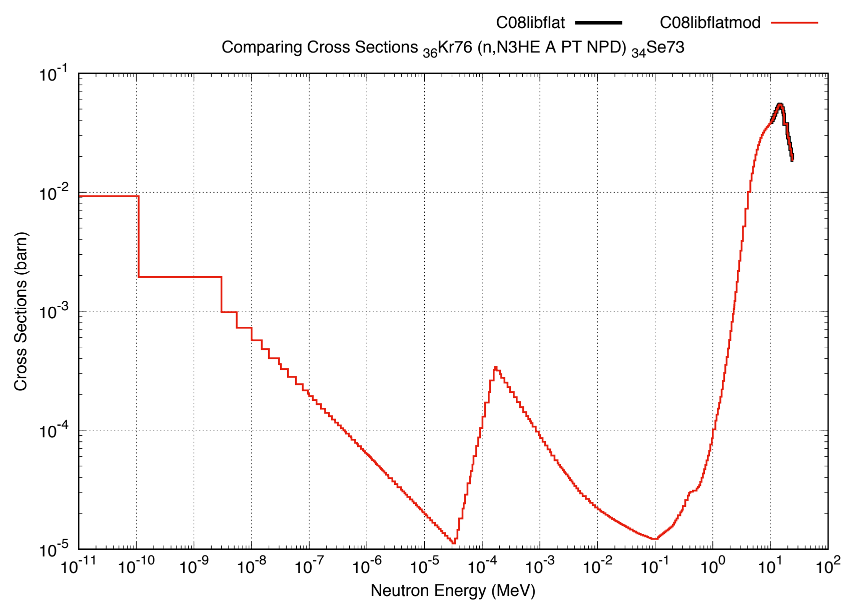


(c)

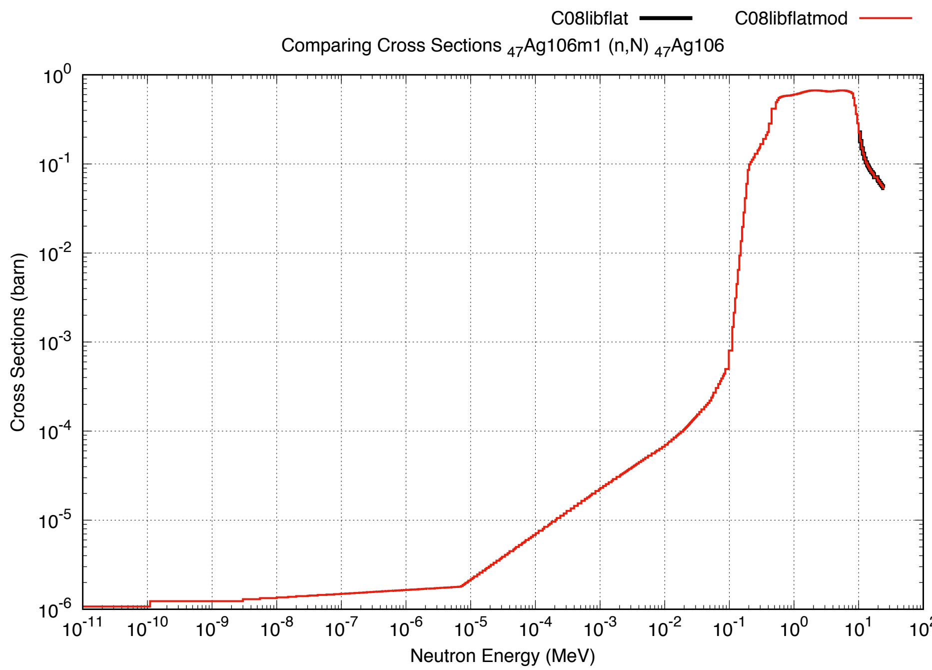
Figure 9. Three reactions with insignificant cross sections not in the current CINDER2008 flat-weighted library but present in the updated CINDER2008 flat-weighted library.

Unlike the fission-weighted library case, there are significant differences between the current and updated flat-weighted libraries for many (2862) reaction cross sections. The majority of them, 2787 reactions, are actually due to the truncating issue of the library maker tool as mentioned above. The full list of the 2787 reactions could be found in Appendix A and a few of those cases are illustrated in Fig. 10. It is obvious that those reaction cross sections in the current CINDER2008 flat-weighted library are truncated below 10 MeV. In contrast, the updated flat-weighted library shows the full range of the cross sections down to the lowest energy group (1E-11 – 1.1E-10 MeV) and fixes the truncation.

(a)

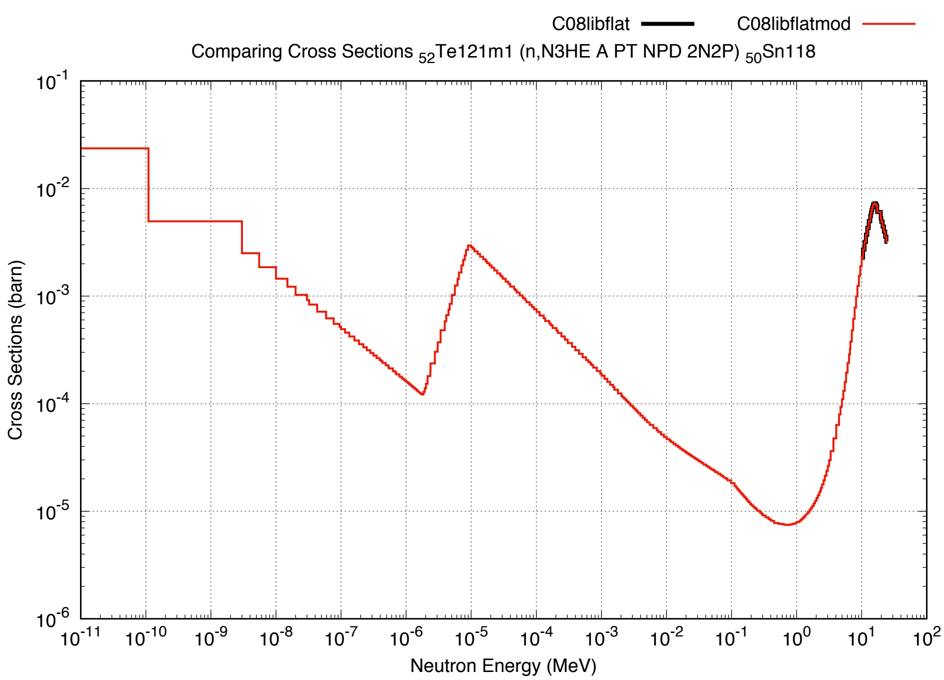


(b)



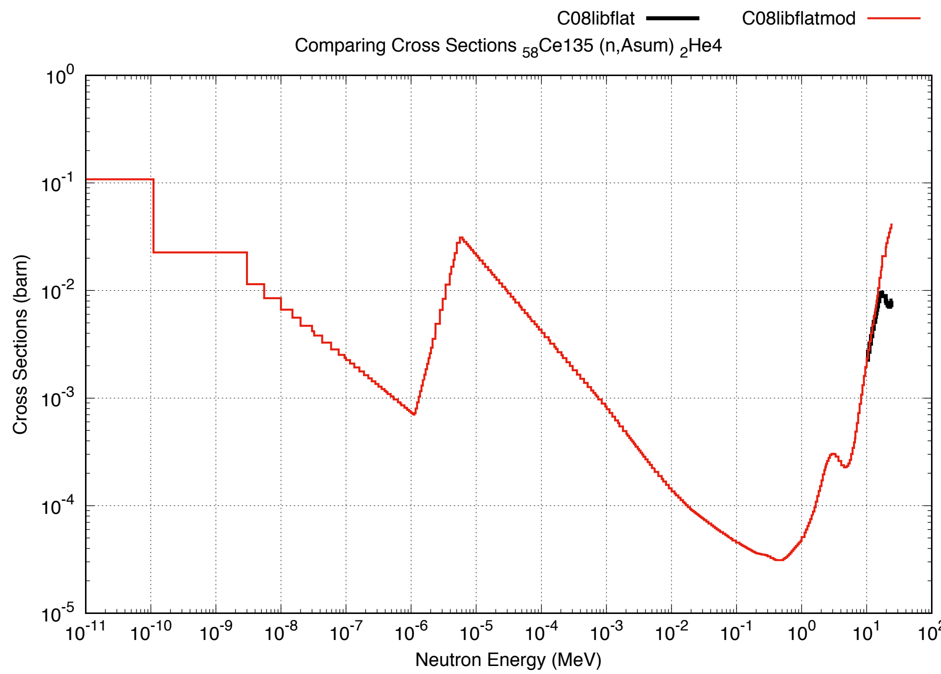
C08libflat
C08libflatmod
Comparing Cross Sections $_{47}$Ag106m1 (n,N) $_{47}$Ag106
Cross Sections (barn)
Neutron Energy (MeV)

(c)

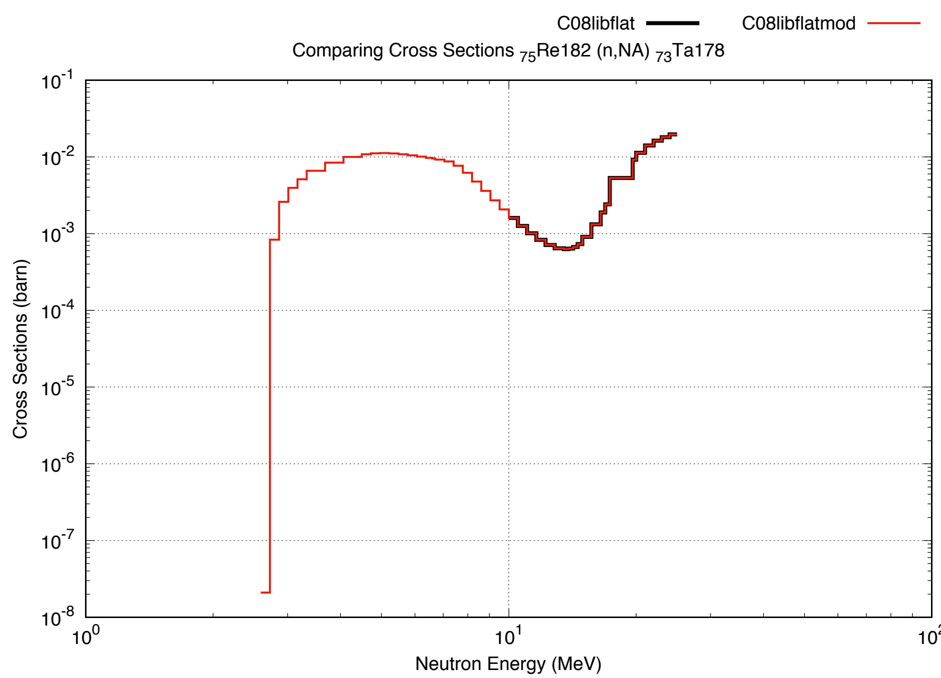


C08libflat
C08libflatmod
Comparing Cross Sections $_{52}$Te121m1 (n,N3HE A PT NPD 2N2P) $_{50}$Sn118
Cross Sections (barn)
Neutron Energy (MeV)

(d)



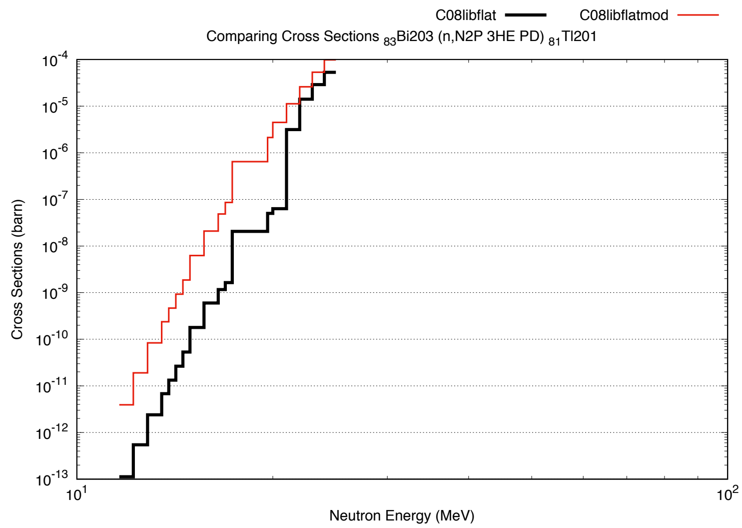
(e)



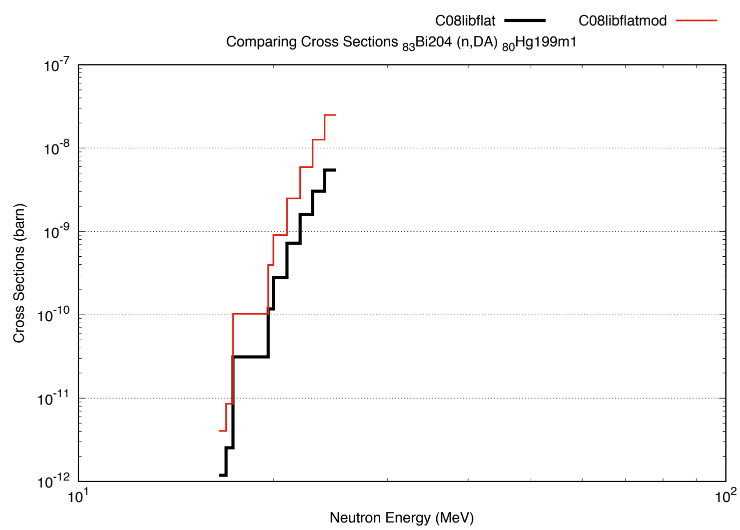
(f)

Figure 10. Examples of reaction cross sections truncated below 10 MeV in the current CINDER2008 flat-weighted library but fixed in the updated CINDER2008 flat-weighted library.

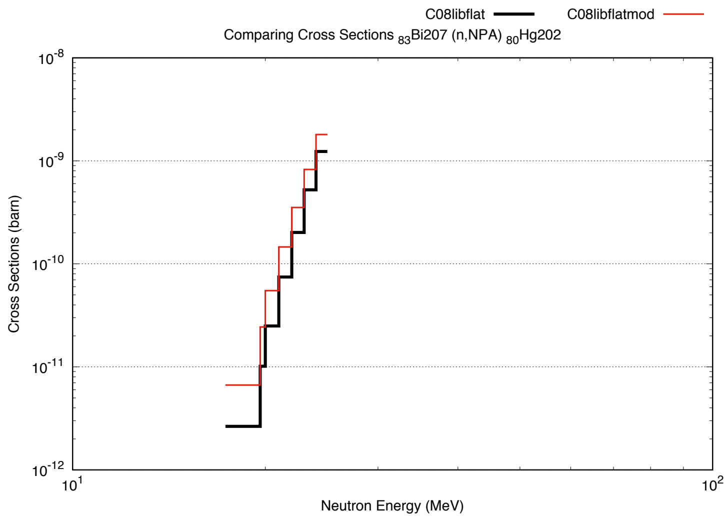
For most of the remaining 75 reaction cross sections, the difference between the current and updated CINDER2008 flat-weighted libraries is just limited to one or two energy groups. Therefore, they do not require further examination. However, for reaction cross sections shown in Fig. 11 whose difference between the current and updated CINDER2008 flat-weighted libraries extends to the whole spectrum, a closer investigation may be necessary.



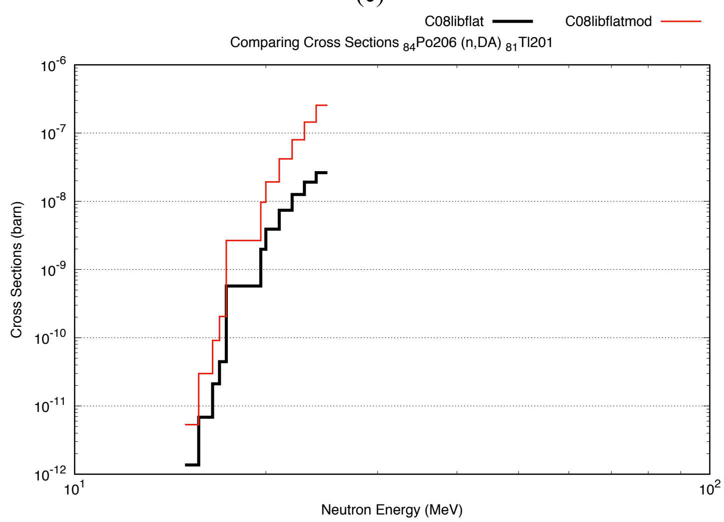
(a)



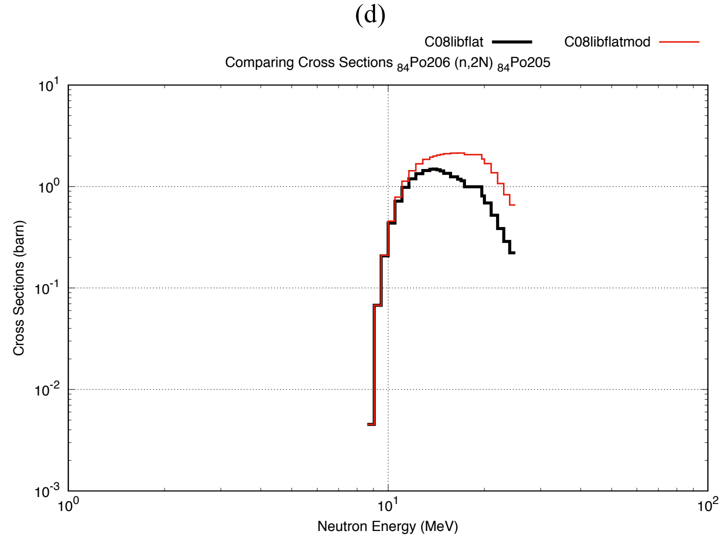
(b)



(c)



(d)



(e)

Figure 11. Reaction cross sections with significant difference between the current and updated CINDER2008 flat-weighted libraries, which my require further examination.

3.3 FUSION-WEIGHTED LIBRARY

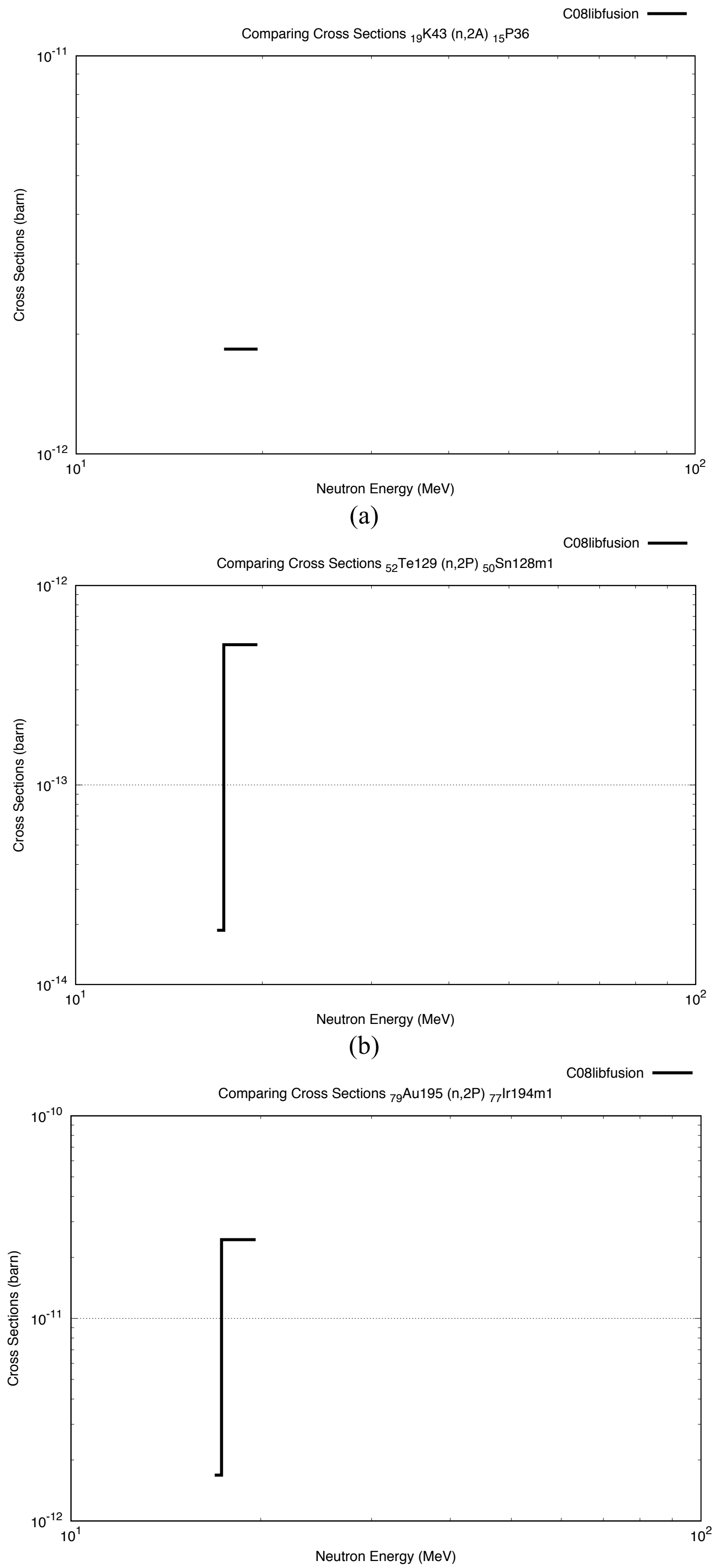
The fusion-weighted library in CINDER2008 has a significantly different energy binning than those in the fission- and flat-weighted libraries. Particularly, the lowest energy group of the fusion spectrum spans four orders of magnitude (1E-11 – 1E-7 MeV). For the purpose of illustration, the plots in this section for reaction cross sections covering the complete fusion spectrum stop at 1E-8 MeV. However, the fusion-weighted library in CINDER2008 has the same truncation issues as the flat-weighted library. So the results of the fusion-weighted library is comparable to those of the flat-weighted library in Section 3.2 and are discussed below.

There are 101 reaction cross sections, as listed in Table 8, present in the current CINDER2008 fusion-weighted library but not in the updated one. The discussions for each reaction cross section in Table 8 marked (*), (†), (‡) or (**) are the same as those in Section 3.1 and 3.2. The majority (72) of the reaction cross sections are marked (**), which means that, as discussed in Section 3.2, they are included in EAF-2010 but they only involve one or two highest energy groups with insignificant cross sections around 1E-12 barn, the cut-off limit of the CINDER2008 library maker tool. Three cases of such reaction cross sections are shown as examples in Fig. 12. Again this is probably due to the treatment of the cut-off limit in the library maker tool.

Table 8. List of 101 reaction cross sections in the current CINDER2008 fusion-weighted library but not in the updated CINDER2008 fusion-weighted library.

Target Nucl.	Reactions	Product Nucl.	Target Nucl.	Reactions	Product Nucl.
*30Zn62	(n,2N)	30Zn61m1	**53I126	(n,DA)	50Sn121m1
*30Zn62	(n,2N)	30Zn61m2	**53I128	(n,TA)	50Sn122
*30Zn62	(n,2N)	30Zn61m3	**54Xe127	(n,N2A)	50Sn119
*52Te129	(n,2N)	52Te128m1	**56Ba131	(n,N2A)	52Te123
*56Ba129	(n,ND 2NP T)	55Cs127m1	**56Ba133m1	(n,TA)	53I127
*56Ba129	(n,G)	56Ba130m1	**58Ce137	(n,N2A)	54Xe129m1
*58Ce134	(n,NA)	56Ba130m1	**58Ce137	(n,TA)	55Cs131
*58Ce137	(n,2N)	58Ce136m1	**60Nd140	(n,NT)	59Pr137
*58Ce137	(n,G)	58Ce138m1	**60Nd141	(n,TA)	57La135
*61Pm143	(n,NPA DA)	58Ce138m1	**65Tb157	(n,N2A)	61Pm149
*61Pm143	(n,2N)	61Pm142m1	**67Ho163	(n,NPA)	64Gd158
*65Tb152	(n,NA)	63Eu148m1	**68Er161	(n,NPA)	65Tb156m1
*65Tb152	(n,G)	65Tb153m1	**68Er161	(n,NPA)	65Tb156m2
*74W181	(n,2N)	74W180m1	**68Er172	(n,X\3HE)	2He3
*79Au198	(n,G)	79Au199m1	**68Er172	(n,3HE)	66Dy170
*82Pb202	(n,G)	82Pb203m2	**69Tm171	(n,3NA)	67Ho165
*83Bi203	(n,2NA)	81Tl198m2	**72Hf170	(n,TA)	69Tm164
*83Bi203	(n,NA)	81Tl199m1	**72Hf170	(n,TA)	69Tm164m1
*84Po206	(n,NPA DA)	81Tl201m1	**72Hf173	(n,3NA)	70Yb167

Target Nucl.	Reactions	Product Nucl.	Target Nucl.	Reactions	Product Nucl.
*84Po206	(n,2N)	84Po205m1	**72Hf178m2	(n,2P)	70Yb177m1
*84Po206	(n,2N)	84Po205m2	**73Ta180m1	(n,N2A)	69Tm172
*85At211	(n,2A)	81Tl204m1	**75Re188	(n,3NA)	73Ta182m1
*85At211	(n,2NA)	83Bi206m1	**75Re188	(n,3NA)	73Ta182m2
*85At211	(n,NA)	83Bi207m1	**76Os185	(n,3NA)	74W179m1
†28Ni57	(n,2NA)	26Fe52	**76Os191m1	(n,3NA)	74W185m1
‡73Ta180	(n,3N)	73Ta178m1	**78Pt189	(n,2N2A)	74W180
‡74W181	(n,NT)	73Ta178m1	**78Pt189	(n,4NA)	76Os182
‡82Pb202	(n,G)	82Pb203m1	**78Pt194	(n,2A)	74W187
‡83Bi203	(n,2NA)	81Tl198m1	**78Pt195	(n,PA)	75Re191
**19K43	(n,2A)	15P36	**78Pt195	(n,2P)	76Os194
**19K43	(n,PA)	16S39	**79Au195	(n,2P)	77Ir194m1
**20Ca45	(n,PA)	17Cl41	**79Au195	(n,2P)	77Ir194m2
**21Sc48	(n,NT)	20Ca45	**79Au196m2	(n,2P)	77Ir195m1
**26Fe52	(n,DA)	23V47	**80Hg193	(n,2N2A)	76Os184
**28Ni57	(n,DA)	25Mn52m1	**80Hg195	(n,NPA)	77Ir190
**28Ni57	(n,P3HE)	25Mn54	**80Hg203	(n,X\3HE)	2He3
**33As71	(n,3P)	30Zn69	**80Hg203	(n,3HE)	78Pt201
**33As77	(n,2NA)	31Ga72m1	**81Tl199	(n,NPA)	78Pt194
**43Tc95	(n,TA)	40Zr89	**81Tl201	(n,2P)	79Au200m1
**43Tc96	(n,N2A)	39Y88	**82Pb200	(n,NPA)	79Au195m1
**46Pd112	(n,X\3HE)	2He3	**82Pb209	(n,X\3HE)	2He3
**46Pd112	(n,3HE)	44Ru110	**82Pb209	(n,3HE)	80Hg207
**49In111	(n,N2A)	45Rh103	**83Bi203	(n,A)	81Tl200m1
**50Sn119m1	(n,PA)	47Ag115m1	**83Bi203	(n,3HE)	81Tl201m1
**50Sn119m1	(n,NT)	49In116m1	**83Bi205	(n,TA)	80Hg199m1
**50Sn119m1	(n,NT)	49In116m2	**83Bi207	(n,TA)	80Hg201
**50Sn121	(n,2P)	48Cd120	**83Bi210	(n,NPA)	80Hg205
**50Sn121	(n,NT)	49In118	**91Pa228	(n,2NT)	90Th224
**50Sn121m1	(n,NT)	49In118	**100Fm252	(n,3N2A)	96Cm242
**52Te121m1	(n,TA)	49In115	**100Fm257	(n,N2A)	96Cm249
**52Te129	(n,2P)	50Sn128m1			



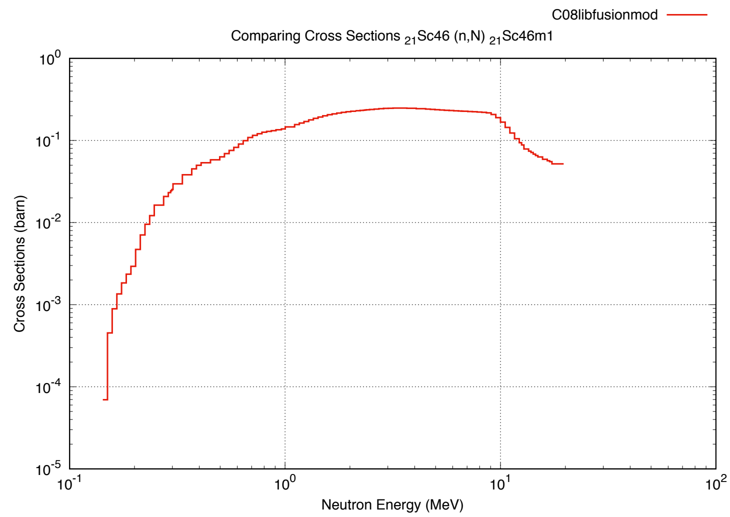
(a)

(b)

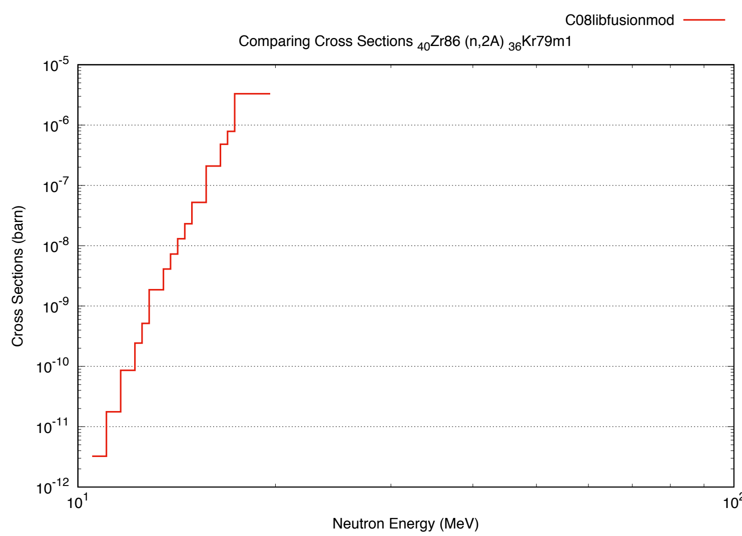
(c)

Figure 12. Examples of reaction cross sections presentin the current CINDER2008 fusion-weighted library but not in the updated CINDER2008 fusion-weighted library.

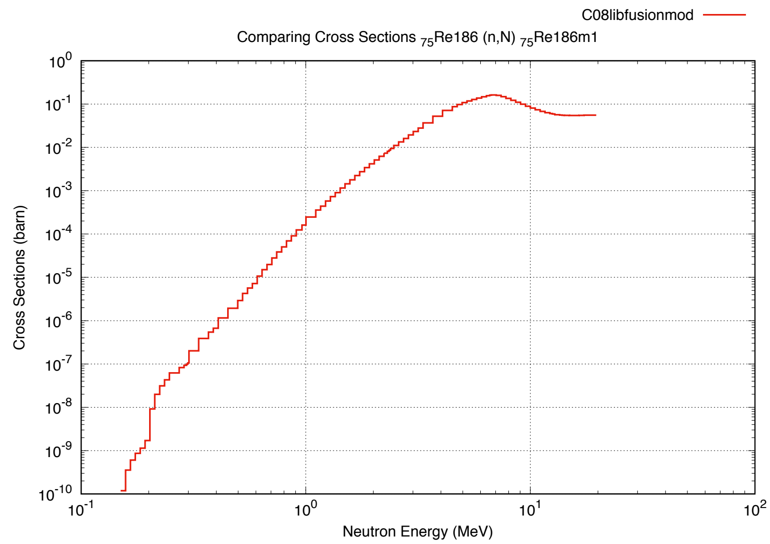
On the other side, there are 6 reaction cross sections present in the updated CINDER2008 fusion-weighted library but not in the current one. Four of them, shown in Fig. 13, are actually significant cross sections accidentally missed in the current CINDER2008 fusion-weighted library similar to the case of the current flat-weighted library in Section 3.2. The other 2 reaction cross sections, shown in Fig. 14, are just insignicant cross sections around the cut-off limit of the CINDER2008 library maker tool.



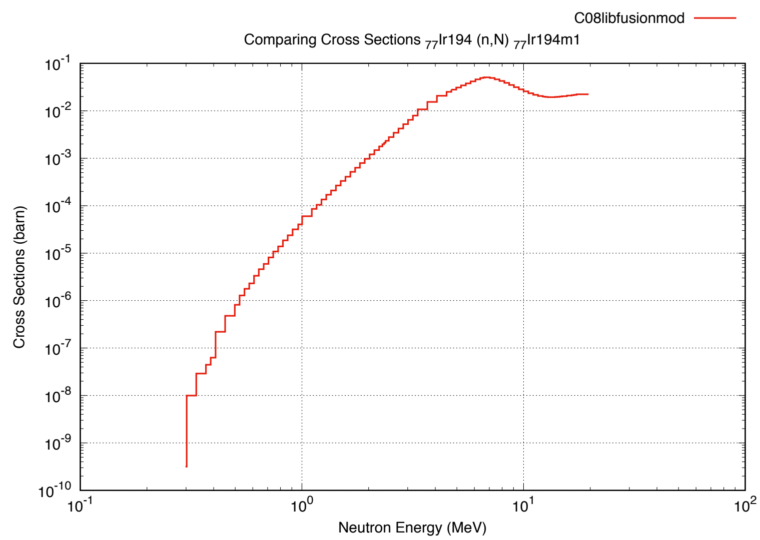
(a)



(b)

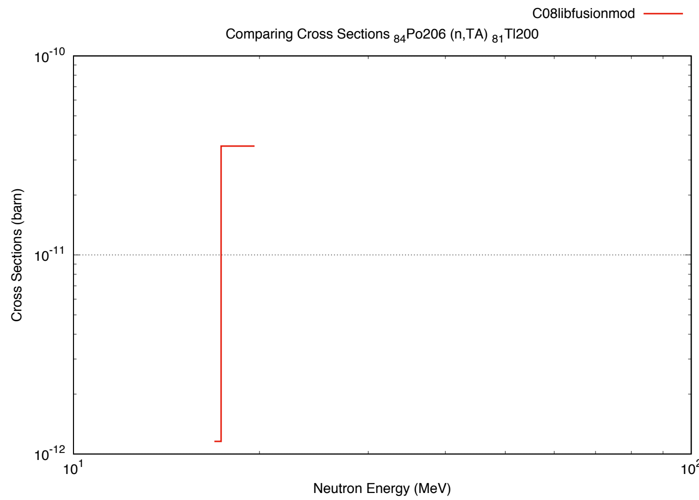


(c)

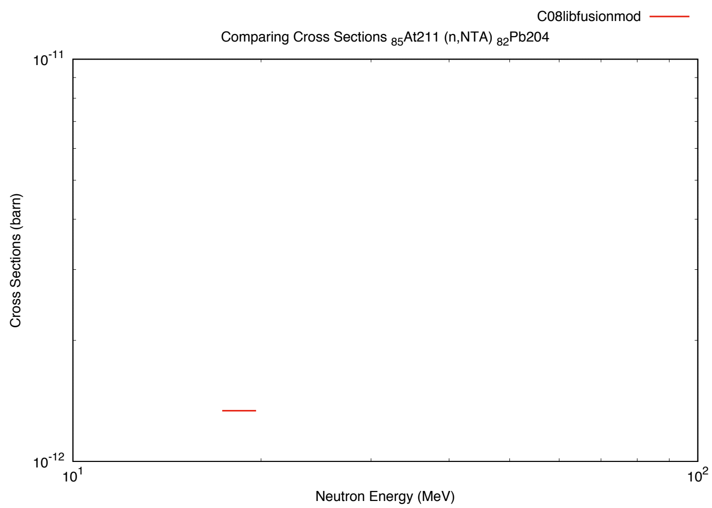


(d)

Figure 13. Reaction cross sections missed in the current CINDER2008 fusion-weighted library but fixed in the updated fusion-weighted library.



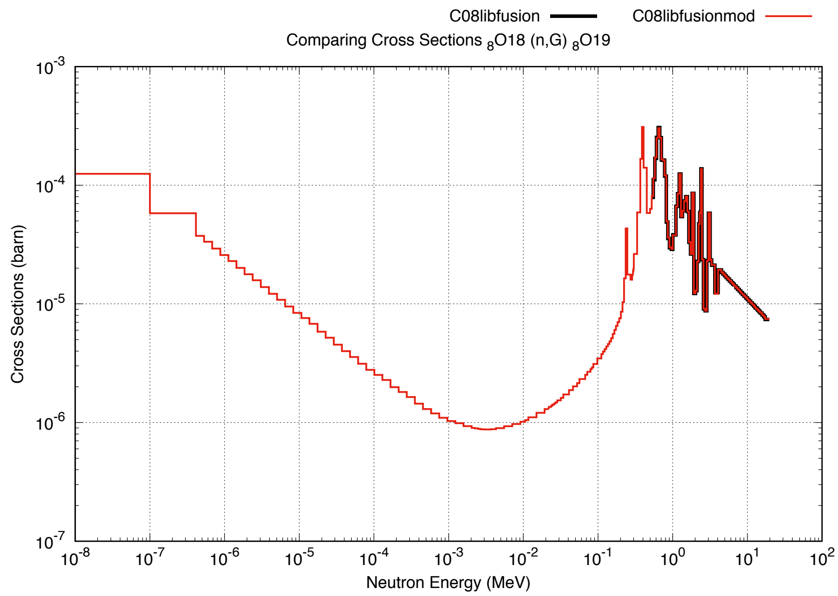
(a)



(b)

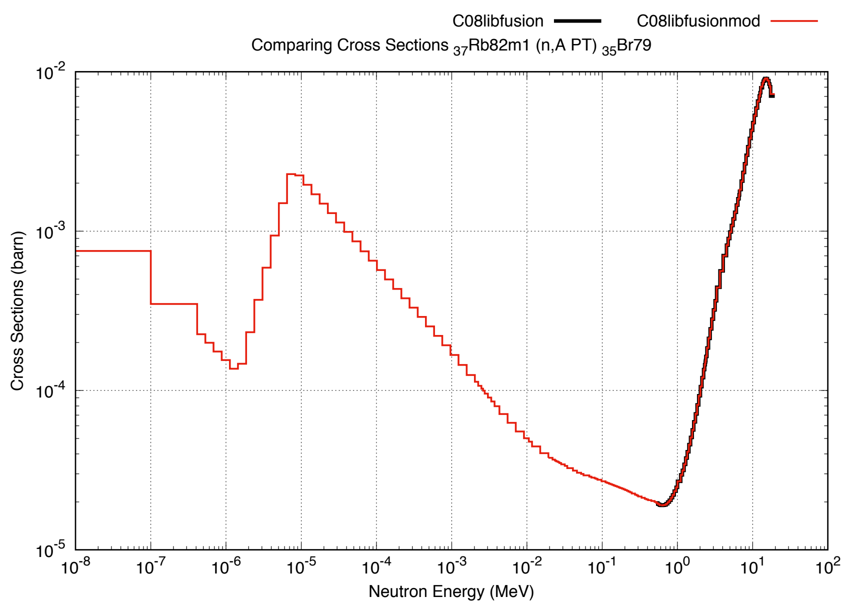
Figure 14. Reaction cross sections with insignificant values not in the current CINDER2008 fusion-weighted library but present in the updated CINDER2008 fusion-weighted library.

Similar to the case of the current flat-weighted library, there are a great number of reaction cross sections showing significant difference between the current and updated CINDER2008 fusion-weighted libraries. The total number of such reaction cross sections is 2701, 1965 of which is due to the truncation issue discussed in the previous section. The full list of the 1965 reaction cross sections could be found in Appendix B. A few examples of such cross sections are illustrated in Fig. 15. They all show the truncation below ~0.6 MeV in the current CINDER2008 fusion-weighted library but the complete spectrum down to the lowest energy group (1E-11 – 1E-7 MeV) in the updated fusion-weighted library.



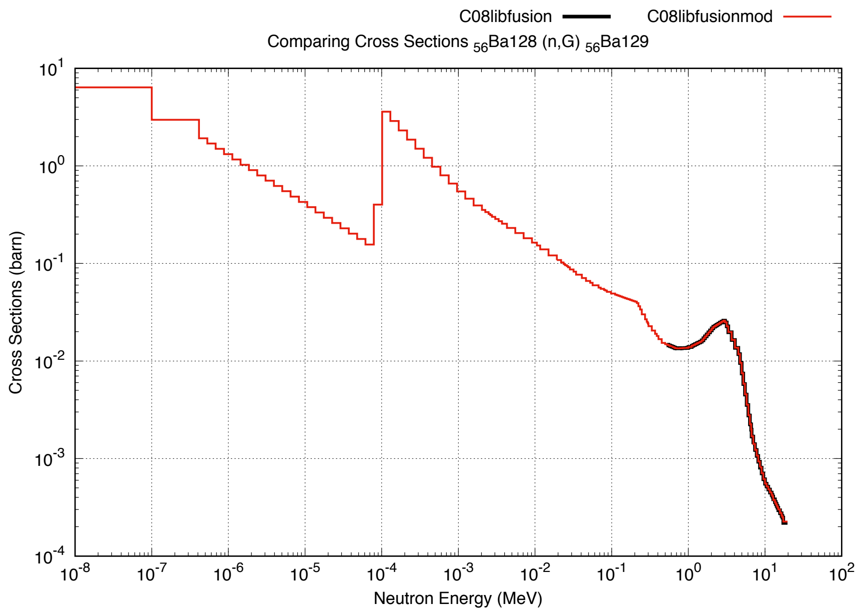
C08libfusion
C08libfusionmod
Comparing Cross Sections 8O18 (n,G) 8O19
Cross Sections (barn)
Neutron Energy (MeV)

(a)

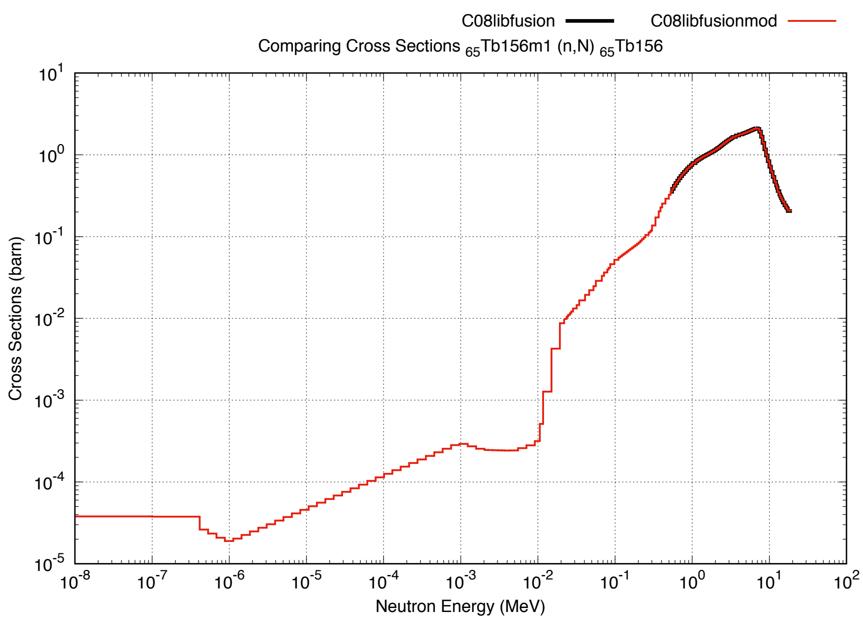


C08libfusion
C08libfusionmod
Comparing Cross Sections 37Rb82m1 (n,A PT) 35Br79
Cross Sections (barn)
Neutron Energy (MeV)

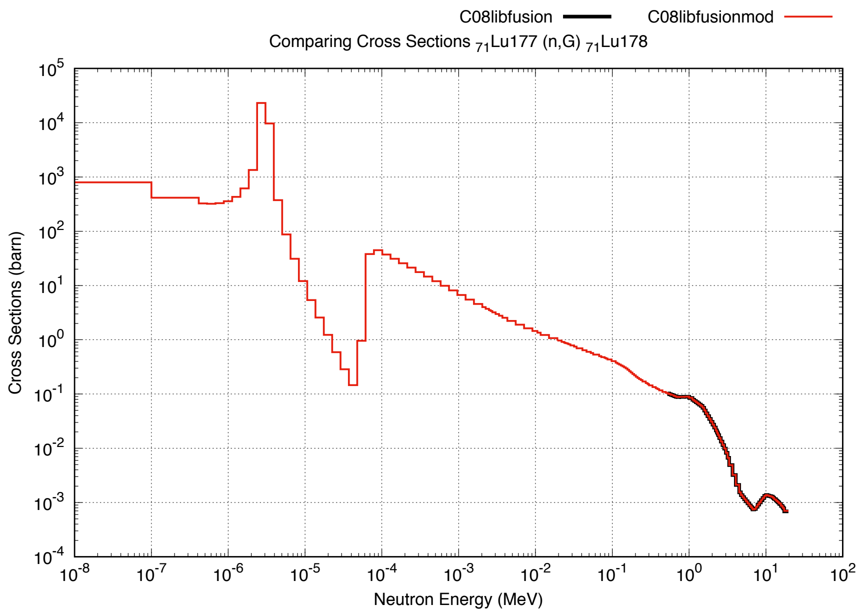
(b)


C08libfusion
C08libfusionmod
Comparing Cross Sections 56Ba128 (n,G) 56Ba129
Cross Sections (barn)
Neutron Energy (MeV)

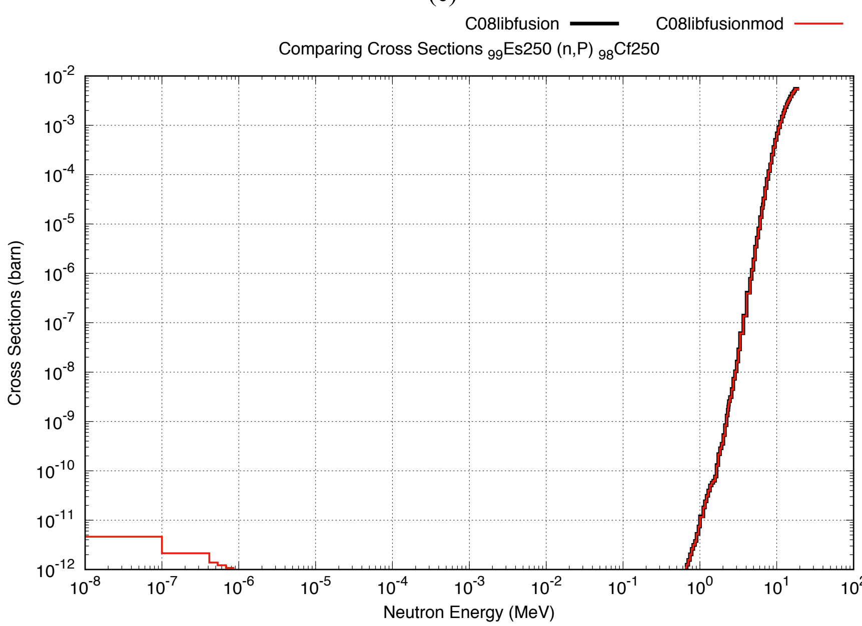
(c)


C08libfusion
C08libfusionmod
Comparing Cross Sections 65Tb156m1 (n,N) 65Tb156
Cross Sections (barn)
Neutron Energy (MeV)

(d)



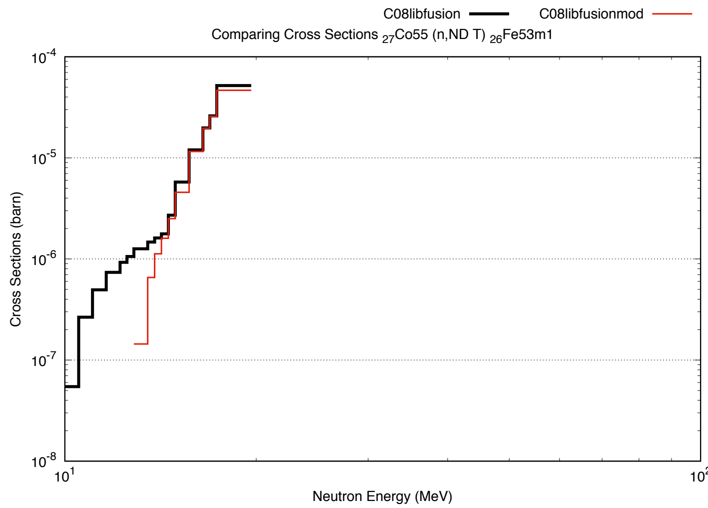
(e)

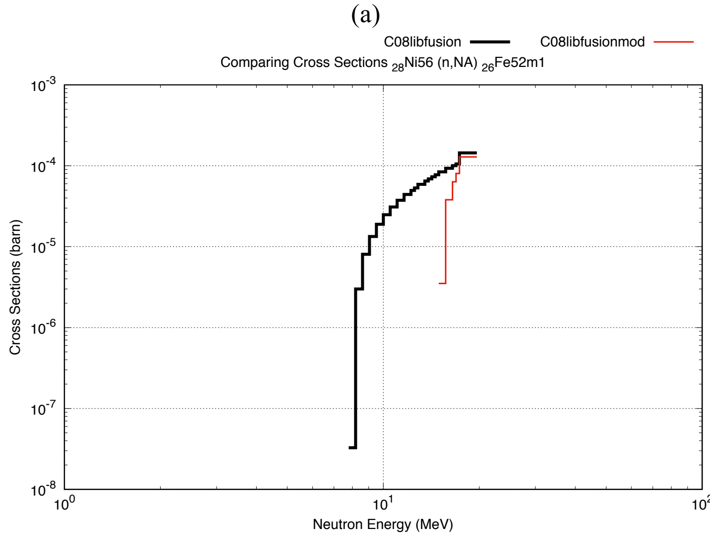


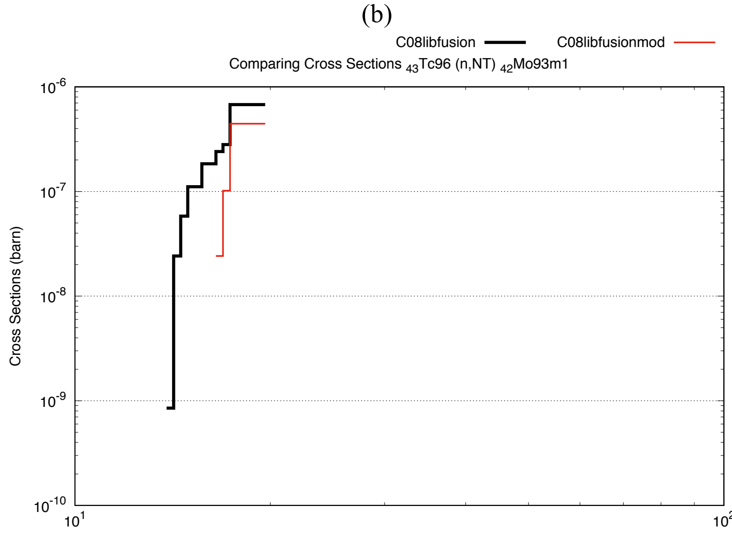
(f)

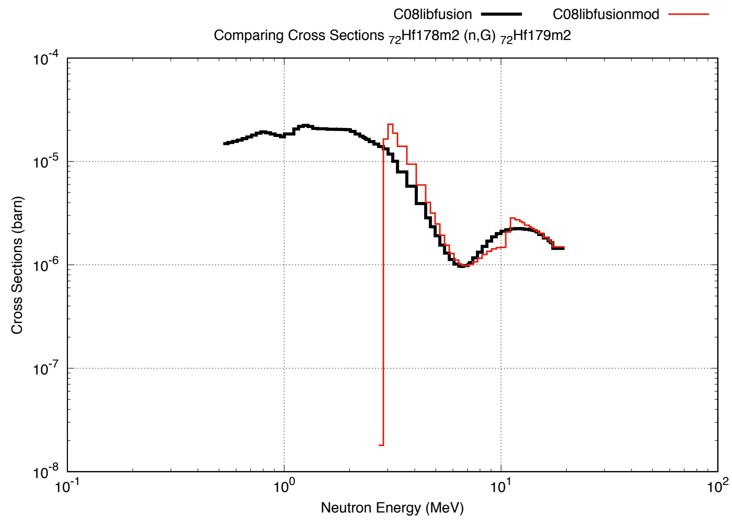
Figure 15. Examples of reaction cross sections truncated below ~0.6 MeV in the current CINDER2008 fusion-weighted library but fixed in the updated CINDER2008 fusion-weighted library (lowest energy bin stops at 1E-8 MeV to illustrate the lowest energy group 1E-11 – 1E-7 MeV).

For the remaining 736 reaction cross sections with significant difference between the current and updated fusion-weighted library, the discrepancy in majority of them is limited to just one or two energy groups. Therefore, they are not of serious concern. However, nine of them as shown in Fig. 16 have reaction cross sections with significant difference covering a big fraction of the compelte spectrum. They may require closer examination.

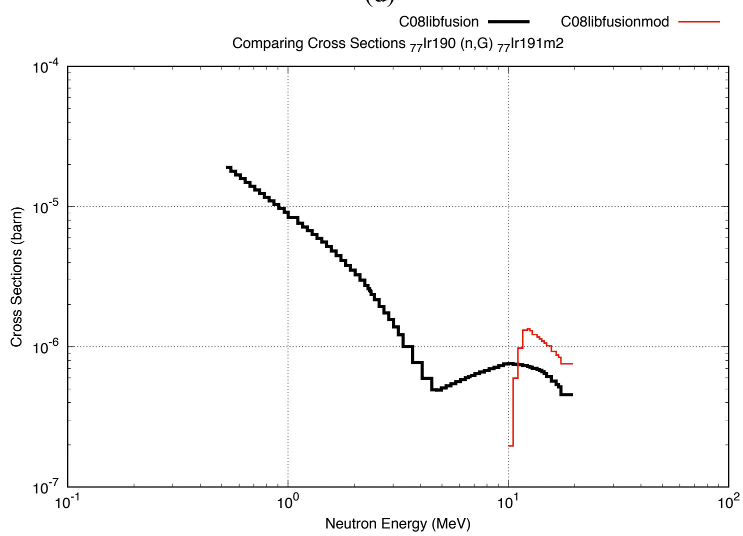

C08libfusion
C08libfusionmod
Comparing Cross Sections 27Co55 (n,ND T) 26Fe53m1
Cross Sections (barn)
Neutron Energy (MeV)
(a)


C08libfusion
C08libfusionmod
Comparing Cross Sections 28Ni56 (n,NA) 26Fe52m1
Cross Sections (barn)
Neutron Energy (MeV)
(b)

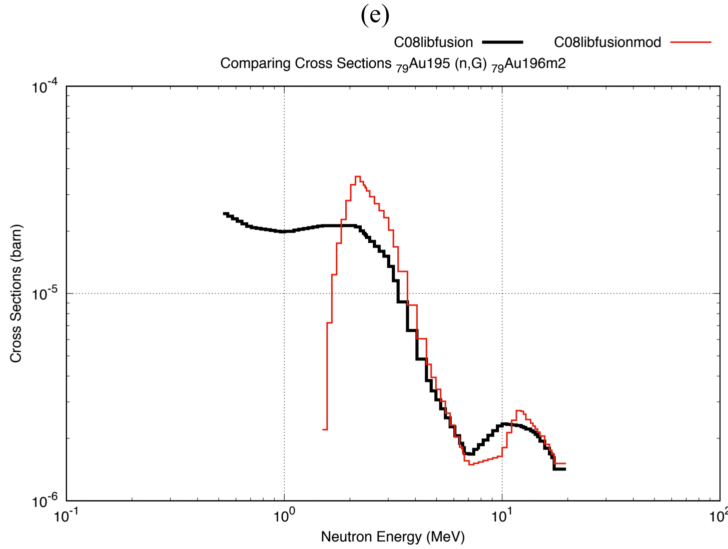

C08libfusion
C08libfusionmod
Comparing Cross Sections 43Tc96 (n,NT) 42Mo93m1
Cross Sections (barn)
Neutron Energy (MeV)
(c)


C08libfusion
C08libfusionmod
Comparing Cross Sections $_{72}$Hf178m2 (n,G) $_{72}$Hf179m2
Cross Sections (barn)
Neutron Energy (MeV)

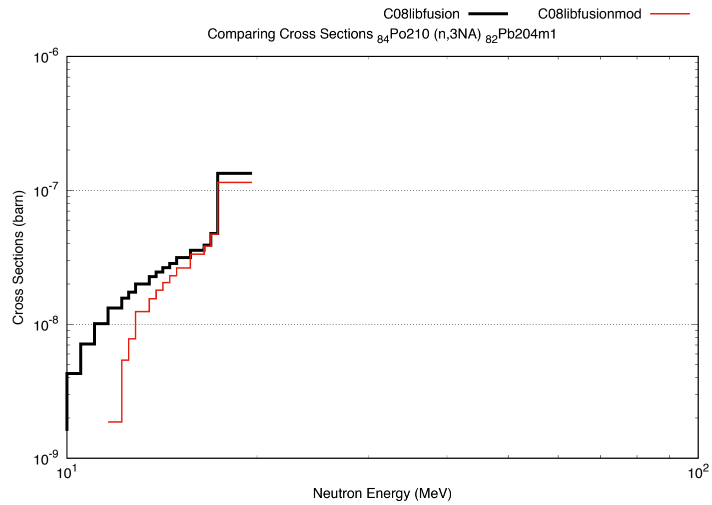
(d)


C08libfusion
C08libfusionmod
Comparing Cross Sections $_{77}$Ir190 (n,G) $_{77}$Ir191m2
Cross Sections (barn)
Neutron Energy (MeV)

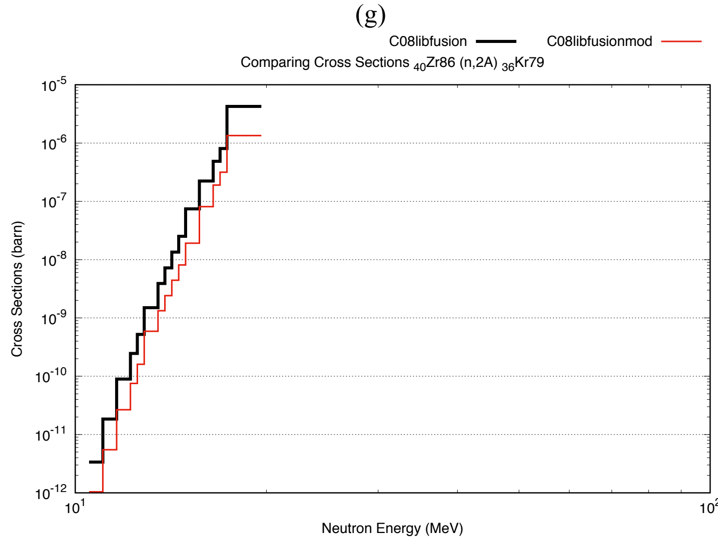
(e)


C08libfusion
C08libfusionmod
Comparing Cross Sections $_{79}$Au195 (n,G) $_{79}$Au196m2
Cross Sections (barn)
Neutron Energy (MeV)

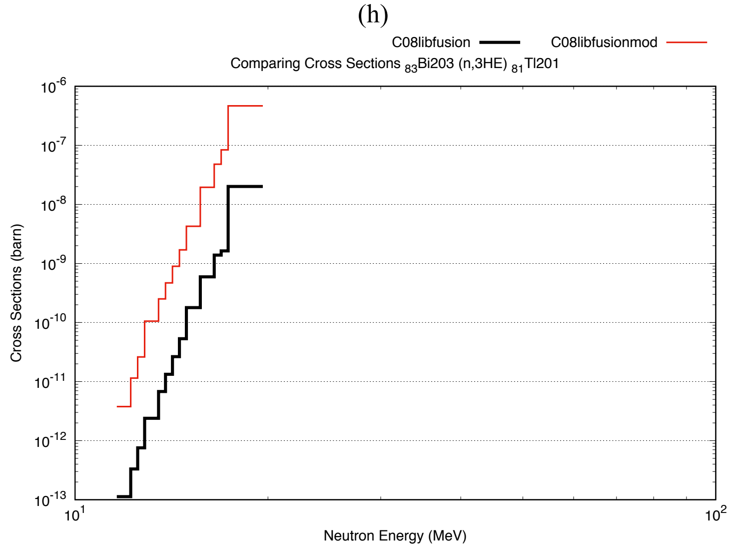
(f)



(g)



(h)



(i)

Figure 16. Reaction cross sections with significant difference between the current CINDER2008 fusion-weighted library and the updated one, which may require further examination.

4. SUMMARY

The recent EAF-2010 cross section data were reprocessed in compatible format into updated libraries for CINDER2008. The results of the updated CINDER2008 cross section libraries were presented and discussed. It is evident that the current version of the CINDER2008 libraries have truncation issues in their flat- and fusion-weighted cross sections taken from EAF-2010, which affect ~15 - 20% of the total reaction cross sections. The updated CINDER2008 libraries using the complete EAF-2010 libraries show results that do not suffer from truncation. However, we find that there are still discrepancies between the current and updated CINDER2008 libraries. This is observed by comparing the results of the fission libraries. Other cross section differences are mainly due to the treatment of the CINDER2008 library maker tool in cutting off insignificant cross sections and in dealing with incomplete isomer cross sections. The library maker tool evolved during the CINDER2008 development therefore the inconsistency lingered.

In general, the differences between the current and updated CINDER2008 libraries are all reasonably accounted and the updated libraries should be used with the CINDER2008 code, rather than the libraries distributed prior to October 2016. The library version can be most reliably distinguished by examining the first line of the (text format) library file. The current libraries show processing dates in March, 2011, while the updated libraries show processing dates in September, 2016.

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APPENDIX A.

List of 2787 truncated reaction cross sections in the current CINDER2008 flat-weighted library but fixed in the updated CINDER2008 flat-weighted library.

Target Nucl.	Reactions
4Be7	(n,X\P) (n,X\A) (n,P) (n,G)
4Be10	(n,G)
6C12	(n,G)
6C13	(n,G)
6C14	(n,G)
8O18	(n,G)
10Ne20	(n,X\A) (n,N3HE PT) (n,G)
10Ne21	(n,X\A) (n,N3HE A PT) (n,G)
10Ne22	(n,G)
11Na24	(n,G)
12Mg28	(n,G)
13Al26	(n,X\P) (n,X\A) (n,N3HE A PT NPD) (n,P) (n,G)
14Si31	(n,G)
14Si32	(n,G)
15P32	(n,X\P) (n,X\A) (n,N3HE PT) (n,P) (n,G)
15P33	(n,G)
16S35	(n,X\A) (n,N3HE A PT) (n,G)
17Cl36	(n,X\P) (n,X\A) (n,N3HE A PT) (n,P) (n,G)
18Ar37	(n,X\P) (n,X\A) (n,N3HE A PT NPD) (n,P) (n,G)
18Ar39	(n,X\A) (n,N3HE A PT NPD) (n,G)
18Ar41	(n,X\A) (n,N3HE PT) (n,G)
18Ar42	(n,G)
19K42	(n,X\P) (n,X\A) (n,N3HE A PT) (n,P) (n,G)
19K43	(n,G)
20Ca41	(n,X\P) (n,X\A) (n,N3HE A PT NPD 2N2P) (n,P) (n,G)
20Ca45	(n,X\A) (n,N3HE PT) (n,G)
20Ca47	(n,G)
21Sc44m1	(n,X\P) (n,X\A) (n,N3HE A PT NPD) (n,P) (n,N) (n,G) (n,G)
21Sc46	(n,X\P) (n,X\A) (n,N3HE A PT) (n,P) (n,N) (n,G)
21Sc47	(n,G)
21Sc48	(n,X\P) (n,P) (n,G)
22Ti44	(n,X\P) (n,X\A) (n,N3HE A PT NPD) (n,P) (n,P) (n,G)
22Ti45	(n,X\P) (n,X\A) (n,N3HE A PT NPD) (n,P) (n,P) (n,G)
23V48	(n,X\P) (n,X\A) (n,N3HE A PT) (n,N3HE A PT) (n,P) (n,G)

Target Nucl.	Reactions
23V49	(n,X\P) (n,X\A) (n,N3HE PT) (n,N3HE PT) (n,P) (n,G)
24Cr48	(n,X\P) (n,X\A) (n,N3HE A PT) (n,P) (n,G)
24Cr51	(n,X\P) (n,X\A) (n,N3HE A PT) (n,P) (n,G)
25Mn52	(n,X\P) (n,X\A) (n,N3HE A PT) (n,P) (n,G)
25Mn53	(n,X\P) (n,X\A) (n,N3HE A PT) (n,P) (n,G)
25Mn54	(n,X\P) (n,X\A) (n,N3HE A PT) (n,P) (n,G)
26Fe52	(n,X\P) (n,X\A) (n,N3HE A PT) (n,P) (n,P) (n,G) (n,G)
26Fe55	(n,X\P) (n,X\A) (n,N3HE A PT) (n,P) (n,G)
26Fe60	(n,G)
27Co55	(n,X\P) (n,X\A) (n,N3HE A PT) (n,N3HE A PT) (n,P) (n,G)
27Co56	(n,X\P) (n,X\A) (n,N3HE A PT NPD) (n,P) (n,G)
27Co57	(n,X\P) (n,X\A) (n,N3HE A PT) (n,P) (n,G) (n,G)
27Co60	(n,X\P) (n,X\A) (n,N3HE A PT) (n,P) (n,N) (n,G)
28Ni56	(n,X\P) (n,X\A) (n,N3HE PT A NPD) (n,N3HE PT) (n,P) (n,G)
28Ni57	(n,X\P) (n,X\A) (n,N3HE A PT NPD) (n,P) (n,G)
28Ni63	(n,X\A) (n,N3HE A PT) (n,G)
28Ni66	(n,G)
29Cu64	(n,X\P) (n,X\A) (n,N3HE A PT) (n,P) (n,G)
29Cu67	(n,G) (n,G)
30Zn62	(n,X\P) (n,X\A) (n,N3HE A PT NPD) (n,P) (n,G)
30Zn69m1	(n,X\A) (n,N3HE A PT) (n,N) (n,G)
30Zn72	(n,G) (n,G) (n,G)
31Ga66	(n,X\P) (n,X\A) (n,2A) (n,PA) (n,N3HE A PT NPD 2N2P) (n,P) (n,G)
31Ga67	(n,X\P) (n,X\A) (n,N3HE A PT) (n,P) (n,G)
31Ga72	(n,X\P) (n,X\A) (n,N3HE A PT) (n,P) (n,G)
32Ge68	(n,X\P) (n,X\A) (n,2A) (n,N3HE A PT NPD) (n,P) (n,G)
32Ge69	(n,X\P) (n,X\A) (n,2A) (n,N3HE A PT NPD 2N2P) (n,P) (n,G)
32Ge71	(n,X\P) (n,X\A) (n,2A) (n,N3HE A PT NPD) (n,P) (n,G)
32Ge77	(n,X\A) (n,N3HE A) (n,N) (n,G)
33As71	(n,X\P) (n,X\A) (n,2A) (n,N3HE A PT) (n,P) (n,P) (n,G)
33As72	(n,X\P) (n,X\A) (n,2A) (n,PA) (n,N3HE A PT NPD 2N2P) (n,P) (n,G)
33As73	(n,X\P) (n,X\A) (n,N3HE A PT) (n,P) (n,P) (n,G)
33As76	(n,X\P) (n,X\A) (n,N3HE A PT) (n,P) (n,G)
33As77	(n,X\A) (n,N3HE) (n,G)
34Se72	(n,X\P) (n,X\A) (n,2A) (n,N3HE A PT NPD) (n,P) (n,G) (n,G)
34Se73	(n,X\P) (n,X\A) (n,2A) (n,N3HE A PT NPD 2N2P) (n,P) (n,N) (n,G)
34Se75	(n,X\P) (n,X\A) (n,2A) (n,N3HE A PT NPD) (n,P) (n,G)
35Br76	(n,X\P) (n,X\A) (n,2A) (n,PA) (n,N3HE A PT NPD) (n,P) (n,N) (n,G) (n,G)

Target Nucl.	Reactions
35Br77	(n,X\P) (n,X\A) (n,N3HE A PT) (n,P) (n,P) (n,N) (n,G)
35Br82	(n,X\P) (n,X\A) (n,N3HE A PT) (n,P) (n,N) (n,G)
36Kr76	(n,X\P) (n,X\A) (n,2A) (n,N3HE A PT NPD) (n,N3HE A PT) (n,P) (n,P) (n,G)
36Kr79	(n,X\P) (n,X\A) (n,2A) (n,N3HE A PT NPD) (n,P) (n,P) (n,N) (n,G)
36Kr81	(n,X\P) (n,X\A) (n,N3HE A PT) (n,P) (n,G)
37Rb82m1	(n,X\P) (n,X\A) (n,2A) (n,N3HE A PT NPD) (n,N3HE A PT NPD) (n,P) (n,G)
37Rb83	(n,X\P) (n,X\A) (n,N3HE A PT) (n,N3HE A PT) (n,P) (n,P) (n,G) (n,G)
37Rb84	(n,X\P) (n,X\A) (n,N3HE A PT) (n,P) (n,G)
38Sr82	(n,X\P) (n,X\A) (n,N3HE A PT) (n,N3HE A PT) (n,P) (n,P) (n,G) (n,G)
38Sr83	(n,X\P) (n,X\A) (n,2A) (n,N3HE A PT NPD 2N2P) (n,P) (n,G)
38Sr85	(n,X\P) (n,X\A) (n,N3HE A PT) (n,P) (n,G)
38Sr91	(n,X\A) (n,N3HE A) (n,G)
39Y86	(n,X\P) (n,X\A) (n,N3HE A PT NPD) (n,P) (n,G) (n,G)
39Y87	(n,X\P) (n,X\A) (n,N3HE A PT) (n,N3HE A PT) (n,P) (n,P) (n,G)
39Y87m1	(n,X\P) (n,X\A) (n,N3HE A PT) (n,N3HE A PT) (n,P) (n,P) (n,N) (n,G)
39Y88	(n,X\P) (n,X\A) (n,N3HE A PT) (n,P) (n,G) (n,G)
39Y93	(n,X\A) (n,N3HE A) (n,A) (n,G)
40Zr86	(n,X\P) (n,X\A) (n,2A) (n,N3HE A PT) (n,N3HE A PT) (n,P) (n,P) (n,G) (n,G)
40Zr88	(n,X\P) (n,X\A) (n,N3HE A PT) (n,N3HE A PT) (n,P) (n,G) (n,G)
40Zr89	(n,X\P) (n,X\A) (n,N3HE A PT) (n,P) (n,P) (n,G) (n,G)
40Zr97	(n,X\A) (n,N3HE A) (n,G)
41Nb90	(n,X\P) (n,X\A) (n,PA) (n,N3HE A PT NPD) (n,N3HE A PT NPD) (n,P) (n,P) (n,N) (n,G)
41Nb91	(n,X\P) (n,X\A) (n,N3HE A PT) (n,P) (n,N) (n,G) (n,G)
41Nb91m1	(n,X\P) (n,X\A) (n,N3HE A PT) (n,P) (n,N) (n,G) (n,G)
41Nb92	(n,X\P) (n,X\A) (n,PA) (n,N3HE A PT NPD) (n,N3HE A PT NPD) (n,P) (n,N) (n,G) (n,G)
41Nb92m1	(n,X\P) (n,X\A) (n,PA) (n,N3HE A PT NPD 2N2P) (n,N3HE A PT NPD) (n,P) (n,N) (n,G) (n,G)
41Nb93m1	(n,X\P) (n,X\A) (n,N3HE A PT) (n,N3HE A PT) (n,P) (n,N) (n,G) (n,G)
41Nb95m1	(n,X\P) (n,X\A) (n,N3HE A PT) (n,P) (n,N) (n,G)
41Nb96	(n,X\P) (n,X\A) (n,N3HE A PT) (n,N3HE A PT) (n,P) (n,G) (n,G)
42Mo93	(n,X\P) (n,X\A) (n,PA) (n,N3HE A PT NPD 2N2P) (n,N3HE A PT) (n,P) (n,P) (n,G)
42Mo93m1	(n,X\P) (n,X\A) (n,PA) (n,PA) (n,N3HE A PT NPD 2N2P) (n,N3HE A PT NPD 2N2P) (n,P) (n,P) (n,G)
43Tc95	(n,X\P) (n,X\A) (n,PA) (n,N3HE A PT NPD) (n,N3HE A PT) (n,P) (n,N) (n,G) (n,G)
43Tc95m1	(n,X\P) (n,X\A) (n,PA) (n,N3HE A PT NPD) (n,N3HE A PT) (n,P) (n,N) (n,G) (n,G)
43Tc96	(n,X\P) (n,X\A) (n,2A) (n,2A) (n,PA) (n,N3HE A PT NPD) (n,N3HE A PT NPD) (n,P) (n,N) (n,G) (n,G)
43Tc97	(n,X\P) (n,X\A) (n,2A) (n,2A) (n,N3HE A PT) (n,N3HE A PT) (n,P) (n,N) (n,G)
43Tc97m1	(n,X\P) (n,X\A) (n,2A) (n,N3HE A PT) (n,N3HE A PT) (n,P) (n,N) (n,G)

Target Nucl.	Reactions
43Tc98	(n,X\P) (n,X\A) (n,2A) (n,2A) (n,N3HE A PT) (n,N3HE A PT) (n,P) (n,G) (n,G)
43Tc99m1	(n,X\P) (n,X\A) (n,N3HE A PT) (n,G)
44Ru97	(n,X\P) (n,X\A) (n,2A) (n,2A) (n,N3HE A PT NPD 2N2P) (n,P) (n,P) (n,G)
45Rh99	(n,X\P) (n,X\A) (n,2A) (n,2A) (n,PA) (n,N3HE A PT NPD) (n,N3HE A PT) (n,P) (n,N) (n,G) (n,G)
45Rh99m1	(n,X\P) (n,X\A) (n,2A) (n,2A) (n,PA) (n,N3HE A PT NPD) (n,N3HE A PT) (n,P) (n,N) (n,G) (n,G)
45Rh100	(n,X\P) (n,X\A) (n,2A) (n,2A) (n,PA) (n,N3HE A PT NPD) (n,N3HE A PT NPD) (n,P) (n,N) (n,G) (n,G)
45Rh101	(n,X\P) (n,X\A) (n,N3HE A PT) (n,P) (n,N) (n,G) (n,G)
45Rh101m1	(n,X\P) (n,X\A) (n,2A) (n,2A) (n,N3HE A PT) (n,P) (n,N) (n,G) (n,G)
45Rh102	(n,X\P) (n,X\A) (n,2A) (n,2A) (n,N3HE A PT) (n,N3HE A PT) (n,P) (n,N) (n,G) (n,G)
45Rh102m1	(n,X\P) (n,X\A) (n,2A) (n,2A) (n,N3HE A PT) (n,N3HE A PT) (n,P) (n,N) (n,G) (n,G)
46Pd100	(n,X\P) (n,X\A) (n,2A) (n,2A) (n,N3HE A PT NPD) (n,P) (n,P) (n,G)
46Pd101	(n,X\P) (n,X\A) (n,2A) (n,PA) (n,PA) (n,N3HE A PT NPD 2N2P) (n,P) (n,P) (n,G)
46Pd103	(n,X\P) (n,X\A) (n,2A) (n,N3HE A PT NPD) (n,P) (n,P) (n,G)
46Pd109	(n,X\A) (n,N3HE A PT) (n,G)
46Pd112	(n,X\A) (n,A) (n,G) (n,G)
47Ag105	(n,X\P) (n,X\A) (n,N3HE A PT) (n,N3HE A PT) (n,P) (n,N) (n,G) (n,G)
47Ag106m1	(n,X\P) (n,X\A) (n,2A) (n,2A) (n,PA) (n,N3HE A PT) (n,N3HE A PT) (n,P) (n,N) (n,G) (n,G)
47Ag108m1	(n,X\P) (n,X\A) (n,N3HE A PT) (n,N3HE A PT) (n,P) (n,N) (n,G) (n,G)
48Cd107	(n,X\P) (n,X\A) (n,2A) (n,N3HE A PT NPD 2N2P) (n,P) (n,P) (n,G)
48Cd109	(n,X\P) (n,X\A) (n,2A) (n,N3HE A PT NPD) (n,P) (n,P) (n,G)
48Cd113m1	(n,X\A) (n,N3HE A PT) (n,N) (n,G)
48Cd115	(n,X\A) (n,N3HE A) (n,G)
49In111	(n,X\P) (n,X\A) (n,N3HE A PT) (n,N3HE A PT) (n,P) (n,P) (n,G)
49In114m1	(n,X\P) (n,X\A) (n,N3HE A PT) (n,N3HE A PT) (n,P) (n,N) (n,G) (n,G)
50Sn117m1	(n,X\P) (n,X\A) (n,N3HE A PT) (n,N) (n,G)
50Sn119m1	(n,X\A) (n,N3HE A PT) (n,N) (n,G)
50Sn121	(n,X\A) (n,N3HE A) (n,N) (n,G)
50Sn121m1	(n,X\A) (n,N3HE A) (n,N) (n,G)
51Sb119	(n,X\P) (n,X\A) (n,N3HE A PT) (n,N3HE A PT) (n,N3HE A PT) (n,P) (n,P) (n,G) (n,G)
51Sb120m1	(n,X\P) (n,X\A) (n,N3HE A PT) (n,N3HE A PT) (n,P) (n,N) (n,G)
51Sb122	(n,X\P) (n,X\A) (n,N3HE A PT) (n,N3HE A PT) (n,P) (n,N) (n,G)
51Sb127	(n,X\A) (n,G) (n,G)
51Sb128	(n,X\P) (n,X\A) (n,A) (n,A) (n,P) (n,G) (n,G)
52Te118	(n,X\P) (n,X\A) (n,2A) (n,2A) (n,NA) (n,N3HE A PT NPD) (n,P) (n,P) (n,G) (n,G)
52Te119	(n,X\P) (n,X\A) (n,2A) (n,PA) (n,PA) (n,NA) (n,N3HE A PT NPD 2N2P) (n,P) (n,P) (n,G)
52Te119m1	(n,X\P) (n,X\A) (n,2A) (n,PA) (n,PA) (n,NA) (n,N3HE A PT NPD 2N2P) (n,P) (n,P)

Target Nucl.	Reactions
	(n,N) (n,G)
52Te121	(n,X\P) (n,X\A) (n,N3HE A PT NPD 2N2P) (n,P) (n,G)
52Te121m1	(n,X\P) (n,X\A) (n,N3HE A PT NPD 2N2P) (n,P) (n,N) (n,G)
52Te123m1	(n,X\P) (n,X\A) (n,N3HE A PT NPD) (n,P) (n,N) (n,G)
52Te125m1	(n,X\P) (n,X\A) (n,N3HE A PT) (n,P) (n,N) (n,G)
52Te127	(n,X\P) (n,X\A) (n,N3HE A) (n,N) (n,G)
52Te129	(n,X\A) (n,N3HE A) (n,N) (n,G)
52Te131m1	(n,X\A) (n,N3HE A) (n,A) (n,N) (n,G)
53I123	(n,X\P) (n,X\A) (n,PA) (n,PA) (n,N3HE A PT) (n,N3HE A PT) (n,P) (n,P) (n,G)
53I124	(n,X\P) (n,X\A) (n,PA) (n,N3HE A PT) (n,P) (n,G)
53I125	(n,X\P) (n,X\A) (n,N3HE A PT) (n,N3HE A PT) (n,P) (n,P) (n,G)
53I126	(n,X\P) (n,X\A) (n,PA) (n,N3HE A PT) (n,P) (n,G)
53I128	(n,X\P) (n,X\A) (n,N3HE A PT) (n,P) (n,G)
53I133	(n,X\A) (n,A) (n,A) (n,G) (n,G)
54Xe122	(n,X\P) (n,X\A) (n,2A) (n,PA) (n,PA) (n,NA) (n,N3HE A PT NPD) (n,N3HE A PT NPD) (n,P) (n,G)
54Xe125	(n,X\P) (n,X\A) (n,2A) (n,PA) (n,N3HE A PT NPD 2N2P) (n,P) (n,G)
54Xe127	(n,X\P) (n,X\A) (n,2A) (n,N3HE A PT) (n,P) (n,G)
54Xe129m1	(n,X\P) (n,X\A) (n,N3HE A PT) (n,P) (n,N) (n,G)
54Xe131m1	(n,X\P) (n,X\A) (n,N3HE A PT) (n,P) (n,N) (n,G)
54Xe133m1	(n,X\P) (n,X\A) (n,N3HE A) (n,N) (n,G) (n,G)
55Cs127	(n,X\P) (n,X\A) (n,2A) (n,PA) (n,PA) (n,N3HE A PT) (n,P) (n,P) (n,G)
55Cs129	(n,X\P) (n,X\A) (n,PA) (n,N3HE A PT) (n,P) (n,P) (n,G) (n,G)
55Cs131	(n,X\P) (n,X\A) (n,N3HE A PT) (n,P) (n,P) (n,G)
55Cs132	(n,X\P) (n,X\A) (n,N3HE A PT) (n,P) (n,G)
56Ba128	(n,X\P) (n,X\A) (n,2A) (n,2A) (n,PA) (n,N3HE A PT) (n,N3HE A PT) (n,P) (n,G) (n,G)
56Ba129	(n,X\P) (n,X\A) (n,2A) (n,PA) (n,N3HE A PT NPD 2N2P) (n,P) (n,N) (n,G)
56Ba131	(n,X\P) (n,X\A) (n,2A) (n,PA) (n,NA) (n,N3HE A PT NPD) (n,P) (n,G)
56Ba133m1	(n,X\P) (n,X\A) (n,N3HE A PT NPD) (n,P) (n,N) (n,G)
56Ba135m1	(n,X\P) (n,X\A) (n,N3HE A PT) (n,P) (n,N) (n,G) (n,G)
56Ba139	(n,X\A) (n,NA) (n,N3HE A) (n,G)
57La135	(n,X\P) (n,X\A) (n,N3HE A PT) (n,P) (n,P) (n,G) (n,G)
57La137	(n,X\P) (n,X\A) (n,N3HE A PT) (n,N3HE A PT) (n,P) (n,P) (n,G)
57La141	(n,X\A) (n,NA) (n,N3HE A) (n,N3HE A) (n,G)
58Ce134	(n,X\P) (n,X\A) (n,2A) (n,2A) (n,PA) (n,PA) (n,NA) (n,N3HE A PT) (n,N3HE A PT) (n,P) (n,G) (n,G)
58Ce135	(n,X\P) (n,X\A) (n,2A) (n,PA) (n,N3HE A PT NPD 2N2P) (n,P) (n,G)
58Ce137	(n,X\P) (n,X\A) (n,2A) (n,PA) (n,NA) (n,NA) (n,N3HE A PT NPD) (n,P) (n,G)
58Ce137m1	(n,X\P) (n,X\A) (n,2A) (n,PA) (n,N3HE A PT NPD) (n,P) (n,N) (n,G)

Target Nucl.	Reactions
60Nd140	(n,X\P) (n,X\A) (n,2A) (n,PA) (n,PA) (n,N3HE A PT) (n,N3HE A PT) (n,P) (n,G) (n,G)
60Nd141	(n,X\P) (n,X\A) (n,2A) (n,PA) (n,NA) (n,N3HE A PT NPD) (n,P) (n,G)
60Nd149	(n,X\A) (n,NA) (n,N3HE A) (n,G)
61Pm143	(n,X\P) (n,X\A) (n,PA) (n,PA) (n,N3HE A PT) (n,P) (n,G)
61Pm144	(n,X\P) (n,X\A) (n,2A) (n,PA) (n,NA) (n,N3HE A PT NPD 2N2P) (n,P) (n,G)
61Pm145	(n,X\P) (n,X\A) (n,2A) (n,NPA) (n,PA) (n,NA) (n,N3HE A PT) (n,N3HE A PT) (n,P) (n,G)
61Pm146	(n,X\P) (n,X\A) (n,2A) (n,NDA 2NPA) (n,PA) (n,NA) (n,NA) (n,N3HE A PT) (n,P) (n,G)
61Pm150	(n,X\P) (n,X\A) (n,NA) (n,N3HE A) (n,P) (n,G)
62Sm145	(n,X\P) (n,X\A) (n,2A) (n,PA) (n,NA) (n,NA) (n,N3HE A PT NPD 2N2P) (n,P) (n,G)
62Sm146	(n,X\P) (n,X\A) (n,2A) (n,2A) (n,PA) (n,PA) (n,NA) (n,N3HE A PT) (n,G)
62Sm156	(n,X\A) (n,N3HE A) (n,G)
63Eu145	(n,X\P) (n,X\A) (n,2A) (n,2A) (n,PA) (n,PA) (n,NA) (n,N3HE A PT NPD) (n,P) (n,G)
63Eu146	(n,X\P) (n,X\A) (n,2A) (n,PA) (n,NA) (n,N3HE A PT NPD 2N2P) (n,P) (n,G)
63Eu147	(n,X\P) (n,X\A) (n,2A) (n,PA) (n,NA) (n,N3HE A PT NPD) (n,P) (n,G)
63Eu148	(n,X\P) (n,X\A) (n,2A) (n,PA) (n,NA) (n,N3HE A PT NPD 2N2P) (n,P) (n,G)
63Eu149	(n,X\P) (n,X\A) (n,N2A) (n,2A) (n,2A) (n,NPA) (n,PA) (n,NA) (n,N3HE A PT) (n,P) (n,G) (n,G)
63Eu150	(n,X\P) (n,X\A) (n,2A) (n,NDA 2NPA) (n,NPA) (n,PA) (n,NA) (n,N3HE A PT) (n,P) (n,N) (n,G)
63Eu150m1	(n,X\P) (n,X\A) (n,2A) (n,NDA 2NPA) (n,NPA) (n,PA) (n,NA) (n,N3HE A PT) (n,P) (n,N) (n,G)
63Eu152m1	(n,X\P) (n,X\A) (n,PA) (n,NA) (n,NA) (n,N3HE A) (n,P) (n,N) (n,N) (n,G)
64Gd146	(n,X\P) (n,X\A) (n,2A) (n,2A) (n,PA) (n,NA) (n,N3HE A PT NPD 2N2P) (n,P) (n,G)
64Gd147	(n,X\P) (n,X\A) (n,2A) (n,3HEA) (n,PA) (n,NA) (n,N3HE A PT NPD 2N2P) (n,P) (n,G)
64Gd148	(n,X\P) (n,X\A) (n,2A) (n,2A) (n,PA) (n,NA NPT) (n,N3HE A PT NPD 2N2P) (n,P) (n,G)
64Gd149	(n,X\P) (n,X\A) (n,2A) (n,PA) (n,NA) (n,N3HE A PT NPD 2N2P) (n,P) (n,G)
64Gd150	(n,X\P) (n,X\A) (n,N2A) (n,2A) (n,PA) (n,NA) (n,N3HE A PT) (n,G)
64Gd151	(n,X\P) (n,X\A) (n,N2A) (n,2A) (n,PA) (n,NA) (n,N3HE A PT NPD 2N2P) (n,P) (n,G)
64Gd159	(n,X\A) (n,N3HE A) (n,G)
65Tb151	(n,X\P) (n,X\D) (n,X\A) (n,N2A) (n,2A) (n,NDA 2NPA) (n,DA) (n,PA) (n,NA) (n,N3HE A PT NPD 2N2P) (n,NP) (n,P) (n,N) (n,G) (n,G)
65Tb152	(n,X\P) (n,X\A) (n,N2A) (n,2A) (n,PA) (n,NA) (n,N3HE A PT NPD 2N2P) (n,P) (n,G)
65Tb153	(n,X\P) (n,X\A) (n,N2A) (n,2A) (n,PA) (n,NA) (n,N3HE A PT) (n,N3HE A PT) (n,P) (n,G) (n,G) (n,G)
65Tb154	(n,X\P) (n,X\A) (n,2A) (n,TA NDA 2NPA) (n,PA) (n,NA) (n,NA) (n,N3HE A PT) (n,P) (n,G)
65Tb154m1	(n,X\P) (n,X\A) (n,2A) (n,NPA) (n,PA) (n,NA) (n,NA) (n,N3HE A PT NPD) (n,P) (n,G)
65Tb154m2	(n,X\P) (n,X\A) (n,2A) (n,PA) (n,NA) (n,NA) (n,N3HE A PT NPD) (n,P) (n,N) (n,N) (n,G)
65Tb155	(n,X\P) (n,X\A) (n,NA) (n,N3HE A PT) (n,N3HE A PT) (n,N3HE A PT) (n,P) (n,G) (n,G) (n,G)

Target Nucl.	Reactions
65Tb156	(n,X\P) (n,X\A) (n,PA) (n,NA) (n,NA) (n,NA) (n,N3HE A PT) (n,P) (n,N) (n,N) (n,G)
65Tb156m1	(n,X\P) (n,X\A) (n,PA) (n,NA) (n,NA) (n,NA) (n,N3HE A PT) (n,P) (n,N) (n,N) (n,G)
65Tb156m2	(n,X\P) (n,X\A) (n,NA) (n,NA) (n,NA) (n,N3HE A PT) (n,P) (n,N) (n,N) (n,G)
65Tb157	(n,X\P) (n,X\A) (n,NA) (n,N3HE A) (n,N3HE A) (n,P) (n,G)
65Tb158	(n,X\P) (n,X\A) (n,NA) (n,NA) (n,N3HE A) (n,P) (n,N) (n,G)
65Tb161	(n,X\A) (n,N3HE A) (n,G)
66Dy153	(n,X\P) (n,X\A) (n,2N2A) (n,N2A) (n,2A) (n,NDA 2NPA) (n,PA) (n,NA NPT) (n,N3HE A PT NPD 2N2P) (n,P) (n,G)
66Dy155	(n,X\P) (n,X\A) (n,2A) (n,PA) (n,NA) (n,N3HE A PT NPD 2N2P) (n,P) (n,G)
66Dy157	(n,X\P) (n,X\A) (n,2A) (n,PA) (n,NA) (n,N3HE A PT) (n,P) (n,G)
66Dy165	(n,X\A) (n,N3HE A) (n,N) (n,G)
66Dy166	(n,X\A) (n,N3HE A) (n,G)
67Ho163	(n,X\P) (n,X\A) (n,NA) (n,N3HE A) (n,P) (n,G) (n,G)
67Ho164	(n,X\P) (n,X\A) (n,NA) (n,N3HE A) (n,P) (n,N) (n,G)
67Ho164m1	(n,X\P) (n,X\A) (n,NA) (n,N3HE A) (n,P) (n,N) (n,G)
67Ho166	(n,X\P) (n,X\A) (n,NA) (n,N3HE A) (n,P) (n,N) (n,G)
67Ho166m1	(n,X\P) (n,X\A) (n,NA) (n,N3HE A) (n,P) (n,N) (n,G)
68Er160	(n,X\P) (n,X\A) (n,2A) (n,PA) (n,NA) (n,N3HE A PT) (n,P) (n,P) (n,P) (n,G)
68Er161	(n,X\P) (n,X\A) (n,2A) (n,PA) (n,NA) (n,N3HE A PT NPD 2N2P) (n,P) (n,P) (n,G)
68Er165	(n,X\P) (n,X\A) (n,NA) (n,N3HE A) (n,P) (n,G)
68Er169	(n,X\A) (n,NA) (n,NA) (n,N3HE A) (n,G)
68Er171	(n,X\A) (n,N3HE A) (n,G)
68Er172	(n,X\A) (n,N3HE A) (n,G)
69Tm165	(n,X\P) (n,X\A) (n,2A) (n,PA) (n,NA) (n,NA) (n,N3HE A PT) (n,N3HE A PT) (n,P) (n,G)
69Tm166	(n,X\P) (n,X\A) (n,2A) (n,PA) (n,NA) (n,NA) (n,N3HE A PT) (n,N3HE A PT) (n,P) (n,G)
69Tm167	(n,X\P) (n,X\A) (n,NA) (n,NA) (n,N3HE A) (n,N3HE A) (n,P) (n,P) (n,G)
69Tm168	(n,X\P) (n,X\A) (n,NA) (n,NA) (n,N3HE A) (n,P) (n,G)
69Tm170	(n,X\P) (n,X\A) (n,NA) (n,NA) (n,N3HE A) (n,P) (n,G)
69Tm171	(n,X\P) (n,X\A) (n,NA) (n,N3HE A) (n,N3HE A) (n,G)
69Tm172	(n,X\P) (n,X\A) (n,NA) (n,NA) (n,N3HE A) (n,P) (n,G)
69Tm173	(n,X\A) (n,NA) (n,N3HE A) (n,N3HE A) (n,G)
70Yb166	(n,X\P) (n,X\A) (n,2A) (n,PA) (n,PA) (n,NA) (n,N3HE A PT) (n,P) (n,G)
70Yb169	(n,X\P) (n,X\A) (n,PA) (n,NA) (n,N3HE A PT) (n,P) (n,N) (n,G)
70Yb175	(n,X\A) (n,NA) (n,N3HE A) (n,G) (n,G)
71Lu169	(n,X\P) (n,X\A) (n,2A) (n,2A) (n,PA) (n,NA) (n,N3HE A PT) (n,P) (n,P) (n,N) (n,G) (n,G)
71Lu170	(n,X\P) (n,X\A) (n,2A) (n,2A) (n,NDA 2NPA) (n,PA) (n,NA) (n,N3HE A PT NPD) (n,P) (n,N) (n,G) (n,G)
71Lu171	(n,X\P) (n,X\A) (n,NPA) (n,PA) (n,PA) (n,NA) (n,N3HE A PT) (n,P) (n,N) (n,G)

Target Nucl.	Reactions
71Lu172	(n,X\P) (n,X\A) (n,2A) (n,NPA DA) (n,PA) (n,NA) (n,N3HE A PT) (n,P) (n,N) (n,G)
71Lu173	(n,X\P) (n,X\A) (n,NA) (n,N3HE A) (n,P) (n,G) (n,G)
71Lu174	(n,X\P) (n,X\A) (n,NA) (n,N3HE A) (n,P) (n,N) (n,G)
71Lu174m1	(n,X\P) (n,X\A) (n,NA) (n,N3HE A) (n,P) (n,N) (n,G)
71Lu177	(n,X\P) (n,X\A) (n,NA) (n,N3HE A) (n,G) (n,G)
71Lu177m1	(n,X\P) (n,X\A) (n,NA) (n,A) (n,P) (n,P) (n,N) (n,G) (n,G)
72Hf170	(n,X\P) (n,X\A) (n,2A) (n,PA) (n,NA) (n,N3HE A PT NPD) (n,P) (n,P) (n,G) (n,G)
72Hf171	(n,X\P) (n,X\A) (n,2A) (n,PA) (n,NA) (n,N3HE A PT NPD 2N2P) (n,P) (n,P) (n,G)
72Hf172	(n,X\P) (n,X\A) (n,2A) (n,PA) (n,NA) (n,N3HE A PT) (n,N3HE A PT) (n,P) (n,G)
72Hf173	(n,X\P) (n,X\A) (n,2A) (n,PA) (n,NA) (n,NA) (n,N3HE A PT NPD) (n,P) (n,G)
72Hf175	(n,X\P) (n,X\A) (n,PA) (n,NA) (n,N3HE A) (n,P) (n,G)
72Hf178m2	(n,X\P) (n,X\A) (n,NA) (n,A) (n,P) (n,P) (n,N) (n,N) (n,G) (n,G) (n,G)
72Hf179m2	(n,X\P) (n,X\A) (n,NA) (n,A) (n,A) (n,P) (n,N) (n,N) (n,G) (n,G)
72Hf180m1	(n,X\A) (n,NA) (n,NA) (n,N3HE A) (n,N3HE A) (n,N) (n,G)
73Ta175	(n,X\P) (n,X\A) (n,2A) (n,PA) (n,NA) (n,NA) (n,N3HE A PT) (n,P) (n,G)
73Ta176	(n,X\P) (n,X\A) (n,2A) (n,PA) (n,NA) (n,N3HE A PT) (n,P) (n,G)
73Ta177	(n,X\P) (n,X\A) (n,2A) (n,PA) (n,NA) (n,N3HE A PT) (n,N3HE A PT) (n,P) (n,G)
73Ta179	(n,X\P) (n,X\A) (n,NA) (n,N3HE A) (n,N3HE A) (n,P) (n,G) (n,G)
73Ta180	(n,X\P) (n,X\A) (n,NA) (n,NA) (n,N3HE A) (n,N3HE A) (n,N3HE A) (n,P) (n,P) (n,N) (n,G)
73Ta180m1	(n,X\P) (n,X\A) (n,NA) (n,NA) (n,N3HE A) (n,N3HE A) (n,N3HE A) (n,P) (n,P) (n,N) (n,G)
73Ta183	(n,X\A) (n,NA) (n,N3HE A) (n,N3HE A) (n,G)
73Ta184	(n,X\P) (n,X\A) (n,NA) (n,NA) (n,N3HE A) (n,G)
74W178	(n,X\P) (n,X\A) (n,2A) (n,PA) (n,PA) (n,NA) (n,N3HE A PT) (n,P) (n,G) (n,G)
74W181	(n,X\P) (n,X\A) (n,NA) (n,NA) (n,N3HE A) (n,N3HE A) (n,N3HE A) (n,P) (n,G)
74W185	(n,X\A) (n,NA) (n,N3HE A) (n,N3HE A) (n,G)
74W187	(n,X\A) (n,NA) (n,N3HE A) (n,N3HE A) (n,G)
74W188	(n,X\A) (n,NA) (n,N3HE A) (n,G)
75Re181	(n,X\P) (n,X\A) (n,2A) (n,2A) (n,PA) (n,PA) (n,NA) (n,N3HE A PT) (n,P) (n,G) (n,G)
75Re182	(n,X\P) (n,X\A) (n,TA NDA 2NPA) (n,PA) (n,NA) (n,N3HE A PT) (n,P) (n,N) (n,G)
75Re182m1	(n,X\P) (n,X\A) (n,N2A) (n,N2A) (n,PA) (n,PA) (n,PA) (n,NA NPT) (n,N3HE A PT NPD 2N2P) (n,P) (n,N) (n,G)
75Re183	(n,X\P) (n,X\A) (n,NA) (n,N3HE A) (n,N3HE A) (n,P) (n,P) (n,G) (n,G)
75Re184	(n,X\P) (n,X\A) (n,NA) (n,NA) (n,N3HE A) (n,P) (n,G)
75Re184m1	(n,X\P) (n,X\A) (n,NA) (n,NA) (n,N3HE A) (n,P) (n,N) (n,G)
75Re186	(n,X\P) (n,X\A) (n,NA) (n,NA) (n,NA) (n,N3HE A) (n,P) (n,N) (n,G)
75Re186m1	(n,X\P) (n,X\A) (n,NA) (n,NA) (n,NA) (n,N3HE A) (n,P) (n,N) (n,G)
75Re188	(n,X\P) (n,X\A) (n,NA) (n,N3HE A) (n,P) (n,N) (n,G)
75Re189	(n,X\A) (n,NA) (n,N3HE A) (n,G) (n,G)

Target Nucl.	Reactions
76Os182	(n,X\P) (n,X\A) (n,2A) (n,PA) (n,NA) (n,N3HE A PT) (n,N3HE A PT) (n,P) (n,P) (n,G) (n,G)
76Os183	(n,X\P) (n,X\A) (n,2A) (n,PA) (n,NA) (n,NA) (n,N3HE A PT NPD) (n,P) (n,N) (n,G)
76Os183m1	(n,X\P) (n,X\A) (n,2A) (n,PA) (n,NA) (n,NA) (n,N3HE A PT NPD) (n,P) (n,G)
76Os185	(n,X\P) (n,X\A) (n,PA) (n,NA) (n,N3HE A) (n,P) (n,G)
76Os191	(n,X\A) (n,NA) (n,N3HE A) (n,N) (n,G) (n,G)
76Os191m1	(n,X\A) (n,NA) (n,N3HE A) (n,N) (n,G) (n,G)
76Os193	(n,X\A) (n,N3HE A) (n,G)
76Os194	(n,X\A) (n,NA) (n,N3HE A) (n,G)
77Ir185	(n,X\P) (n,X\A) (n,2A) (n,NDA 2NPA) (n,NDA 2NPA) (n,DA) (n,PA) (n,NA) (n,N3HE A PT) (n,N3HE A PT) (n,P) (n,G) (n,G)
77Ir186	(n,X\P) (n,X\A) (n,2A) (n,DA) (n,PA) (n,NA) (n,NA) (n,N3HE A PT NPD 2N2P) (n,P) (n,N) (n,G)
77Ir187	(n,X\P) (n,X\A) (n,NDA 2NPA) (n,PA) (n,PA) (n,NA) (n,N3HE A PT) (n,N3HE A PT) (n,P) (n,G)
77Ir188	(n,X\P) (n,X\A) (n,PA) (n,NA) (n,NA) (n,N3HE A) (n,P) (n,G)
77Ir189	(n,X\P) (n,X\A) (n,NA) (n,N3HE A) (n,N3HE A) (n,P) (n,P) (n,G)
77Ir190	(n,X\P) (n,X\A) (n,NA) (n,NA) (n,N3HE A) (n,P) (n,P) (n,N) (n,N) (n,G) (n,G)
77Ir192	(n,X\P) (n,X\A) (n,NA) (n,NA) (n,N3HE A) (n,P) (n,N) (n,N) (n,G) (n,G)
77Ir192m2	(n,X\P) (n,X\A) (n,NA) (n,NA) (n,N3HE A) (n,P) (n,P) (n,N) (n,N) (n,G) (n,G)
77Ir193m1	(n,X\P) (n,X\A) (n,NA) (n,N3HE A) (n,N3HE A) (n,N) (n,G) (n,G) (n,G)
77Ir194	(n,X\P) (n,X\A) (n,NA) (n,NA) (n,N3HE A) (n,P) (n,N) (n,G) (n,G)
77Ir194m2	(n,X\P) (n,X\A) (n,NA) (n,NA) (n,A) (n,P) (n,N) (n,N) (n,G) (n,G)
77Ir196m1	(n,X\P) (n,X\A) (n,NA) (n,N3HE A) (n,P) (n,N) (n,G) (n,G)
78Pt188	(n,X\P) (n,X\A) (n,2A) (n,PA) (n,PA) (n,NA) (n,N3HE A PT) (n,P) (n,G)
78Pt189	(n,X\P) (n,X\A) (n,2A) (n,PA) (n,NA) (n,N3HE A PT NPD 2N2P) (n,P) (n,G)
78Pt190	(n,X\P) (n,X\A) (n,NA) (n,N3HE A PT) (n,P) (n,G)
78Pt191	(n,X\P) (n,X\A) (n,2A) (n,NA) (n,N3HE A) (n,P) (n,G)
78Pt192	(n,X\P) (n,X\A) (n,NA) (n,N3HE A) (n,N3HE A) (n,G) (n,G)
78Pt193	(n,X\P) (n,X\A) (n,NA) (n,NA) (n,N3HE A) (n,N3HE A) (n,P) (n,P) (n,N) (n,G)
78Pt193m1	(n,X\P) (n,X\A) (n,NA) (n,NA) (n,N3HE A) (n,N3HE A) (n,P) (n,P) (n,N) (n,G)
78Pt194	(n,X\A) (n,NA) (n,N3HE A) (n,N3HE A) (n,G) (n,G)
78Pt195	(n,X\P) (n,X\A) (n,NA) (n,NA) (n,N3HE A) (n,N3HE A) (n,G)
78Pt195m1	(n,X\P) (n,X\A) (n,NA) (n,NA) (n,N3HE A) (n,N3HE A) (n,P) (n,N) (n,G)
78Pt196	(n,X\A) (n,NA) (n,N3HE A) (n,G) (n,G)
78Pt197	(n,X\A) (n,NA) (n,N3HE A) (n,G)
78Pt198	(n,X\A) (n,NA) (n,N3HE A) (n,G) (n,G)
78Pt200	(n,X\A) (n,A) (n,G)
78Pt202	(n,X\A) (n,A) (n,G)
79Au193	(n,X\P) (n,X\A) (n,NA) (n,N3HE A) (n,P) (n,P) (n,G) (n,G) (n,G)

Target Nucl.	Reactions
79Au194	(n,X\P) (n,X\A) (n,NA) (n,N3HE A) (n,N3HE A) (n,N3HE A) (n,P) (n,N) (n,G) (n,G)
79Au195	(n,X\P) (n,X\A) (n,NA) (n,N3HE A) (n,N3HE A) (n,N3HE A) (n,P) (n,P) (n,G) (n,G) (n,G)
79Au196	(n,X\P) (n,X\A) (n,NA) (n,NA) (n,NA) (n,N3HE A) (n,N3HE A) (n,P) (n,N) (n,N) (n,G) (n,G)
79Au196m2	(n,X\P) (n,X\A) (n,NA) (n,NA) (n,NA) (n,N3HE A) (n,N3HE A) (n,P) (n,G) (n,G)
79Au198	(n,X\P) (n,X\A) (n,NA) (n,NA) (n,NA) (n,N3HE A) (n,N3HE A) (n,P) (n,G)
79Au198m1	(n,X\P) (n,X\A) (n,NA) (n,NA) (n,NA) (n,A) (n,A) (n,P) (n,N) (n,G)
79Au199	(n,X\P) (n,X\A) (n,NA) (n,NA) (n,N3HE A) (n,A) (n,P) (n,G) (n,G)
79Au200m1	(n,X\P) (n,X\A) (n,NA) (n,NA) (n,N3HE A) (n,N3HE A) (n,P) (n,N) (n,G)
80Hg193	(n,X\P) (n,X\A) (n,2A) (n,NDA 2NPA) (n,PA) (n,NA) (n,N3HE A PT) (n,P) (n,P) (n,N) (n,G)
80Hg193m1	(n,X\P) (n,X\A) (n,2A) (n,NDA 2NPA) (n,PA) (n,NA) (n,N3HE A PT NPD) (n,P) (n,P) (n,N) (n,G)
80Hg194	(n,X\P) (n,X\A) (n,NA) (n,N3HE A PT) (n,P) (n,P) (n,P) (n,G) (n,G)
80Hg195	(n,X\P) (n,X\A) (n,2A) (n,NA) (n,N3HE A PT) (n,P) (n,P) (n,G)
80Hg195m1	(n,X\P) (n,X\A) (n,2A) (n,NA) (n,N3HE A PT) (n,P) (n,P) (n,N) (n,G)
80Hg197	(n,X\P) (n,X\A) (n,NA) (n,NA) (n,N3HE A) (n,P) (n,P) (n,G)
80Hg197m1	(n,X\P) (n,X\A) (n,NA) (n,NA) (n,N3HE A) (n,P) (n,P) (n,N) (n,G)
80Hg203	(n,X\A) (n,N3HE A) (n,G)
81Tl199	(n,X\P) (n,X\A) (n,NA) (n,NA) (n,N3HE A) (n,N3HE A) (n,N3HE A) (n,P) (n,P) (n,G)
81Tl200	(n,X\P) (n,X\A) (n,NA) (n,NA) (n,NA) (n,N3HE A) (n,N3HE A) (n,P) (n,G)
81Tl201	(n,X\P) (n,X\A) (n,NA) (n,NA) (n,N3HE A) (n,N3HE A) (n,P) (n,G)
81Tl202	(n,X\P) (n,X\A) (n,NA) (n,NA) (n,N3HE A) (n,P) (n,G)
81Tl203	(n,X\P) (n,X\A) (n,NA) (n,N3HE A) (n,N3HE A) (n,P) (n,G)
81Tl204	(n,X\P) (n,X\A) (n,NA) (n,N3HE A) (n,P) (n,G)
81Tl205	(n,X\P) (n,X\A) (n,NA) (n,N3HE A) (n,G) (n,G)
82Pb200	(n,X\P) (n,X\A) (n,NA) (n,N3HE A PT) (n,N3HE A PT) (n,P) (n,G) (n,G)
82Pb201	(n,X\P) (n,X\A) (n,NA) (n,NA) (n,N3HE A PT) (n,P) (n,G) (n,G)
82Pb202	(n,X\P) (n,X\A) (n,NA) (n,N3HE A) (n,N3HE A) (n,P) (n,G)
82Pb203	(n,X\P) (n,X\A) (n,NA) (n,NA) (n,N3HE A) (n,P) (n,G) (n,G)
82Pb205	(n,X\P) (n,X\A) (n,NA) (n,N3HE A) (n,P) (n,G)
82Pb209	(n,X\A) (n,NA) (n,N3HE A) (n,G)
82Pb210	(n,X\A) (n,NA) (n,N3HE A) (n,G)
82Pb212	(n,X\A) (n,NA) (n,N3HE A) (n,G)
83Bi203	(n,X\P) (n,X\D) (n,X\A) (n,2NPA) (n,2NPA) (n,DA) (n,PA) (n,PA) (n,NA) (n,N3HE A PT) (n,NP) (n,P) (n,P) (n,P) (n,G)
83Bi204	(n,X\P) (n,X\D) (n,X\A) (n,NPA DA) (n,PA) (n,NA) (n,N3HE A PT) (n,NP) (n,NP) (n,P) (n,P) (n,G)
83Bi205	(n,X\P) (n,X\A) (n,PA) (n,NA) (n,N3HE A PT) (n,P) (n,P) (n,G)
83Bi206	(n,X\P) (n,X\A) (n,NA) (n,N3HE A) (n,P) (n,G)

Target Nucl.	Reactions
83Bi207	(n,X\P) (n,X\A) (n,NA) (n,N3HE A) (n,P) (n,P) (n,G) (n,G)
83Bi208	(n,X\P) (n,X\A) (n,NA) (n,N3HE A) (n,P) (n,G)
83Bi210	(n,X\P) (n,X\T) (n,X\A) (n,NA) (n,NA) (n,N3HE A) (n,N3HE A) (n,ND 2NP T) (n,P) (n,G)
83Bi210m1	(n,X\P) (n,X\T) (n,X\A) (n,NA) (n,NA) (n,N3HE A) (n,N3HE A) (n,ND 2NP T) (n,P) (n,N) (n,G)
84Po206	(n,X\P) (n,X\A) (n,2A) (n,2A) (n,NDA 2NPA) (n,PA) (n,NA) (n,NA) (n,N3HE A PT NPD) (n,N3HE A PT) (n,N3HE A PT) (n,P) (n,G) (n,G)
84Po207	(n,X\P) (n,X\3HE) (n,X\A) (n,2A) (n,PA) (n,NA) (n,NA) (n,NA) (n,N3HE A PT NPD 2N2P) (n,N3HE A PT NPD 2N2P) (n,N2P PD) (n,N2P PD) (n,2P) (n,P) (n,G)
84Po208	(n,X\P) (n,X\3HE) (n,X\A) (n,2A) (n,NDA 2NPA) (n,PA) (n,NA) (n,NA) (n,N3HE A PT NPD) (n,N3HE A PT) (n,N2P PD) (n,P) (n,P) (n,G)
84Po209	(n,X\P) (n,X\3HE) (n,X\A) (n,2A) (n,PA) (n,NA) (n,NA) (n,N3HE A PT NPD 2N2P) (n,N2P PD 3HE) (n,N2P PD) (n,P) (n,G)
84Po210	(n,X\P) (n,X\A) (n,NDA) (n,PA) (n,NA) (n,N3HE A) (n,N3HE A) (n,G) (n,G)
85At210	(n,X\P) (n,X\D) (n,X\A) (n,2A) (n,TA NDA 2NPA) (n,TA NDA 2NPA) (n,NPA DA) (n,NPA DA) (n,PA) (n,NA) (n,N3HE A PT NPD 2N2P) (n,NP) (n,P) (n,G)
85At211	(n,X\P) (n,X\D) (n,X\3HE) (n,X\A) (n,2A) (n,TA NDA 2NPA) (n,TA NDA 2NPA) (n,NPA DA) (n,PA) (n,PA) (n,NA) (n,N3HE A PT NPD) (n,N3HE A PT) (n,N2P PD) (n,NP) (n,P) (n,P) (n,G) (n,G)
86Rn211	(n,X\P) (n,X\3HE) (n,X\A) (n,N2A) (n,N2A) (n,N2A) (n,2A) (n,2A) (n,TA NDA 2NPA) (n,NPA DA) (n,PA) (n,NA NPT) (n,NA) (n,N3HE A PT NPD 2N2P) (n,N2P 3HE PD) (n,2P) (n,P) (n,G)
86Rn222	(n,X\A) (n,2N2A) (n,N2A) (n,2NA) (n,NA) (n,N3HE A) (n,G)
88Ra228	(n,X\A) (n,NA) (n,N3HE A) (n,G)
89Ac228	(n,X\P) (n,X\A) (n,2NA) (n,NA) (n,N3HE A) (n,P) (n,G)
91Pa228	(n,X\P) (n,X\A) (n,N3A) (n,2N2A) (n,N2A) (n,2A) (n,TA NDA 2NPA) (n,NPA DA) (n,PA) (n,2NA) (n,NA) (n,N3HE A) (n,P) (n,G)
91Pa234	(n,X\P) (n,X\A) (n,NA) (n,N3HE A) (n,P) (n,G)
93Np236m1	(n,X\P) (n,X\A) (n,NA) (n,N3HE A) (n,P) (n,G)
94Pu234	(n,X\P) (n,X\A) (n,2N2A) (n,N2A) (n,2A) (n,NA) (n,N3HE A) (n,P) (n,G)
94Pu245	(n,X\A) (n,2NA) (n,NA) (n,N3HE A) (n,G)
94Pu247	(n,X\A) (n,NA) (n,N3HE A)
95Am239	(n,X\P) (n,X\A) (n,N2A) (n,2A) (n,NA) (n,N3HE A) (n,N3HE A) (n,P) (n,G)
97Bk248m1	(n,X\P) (n,X\A) (n,2A) (n,2NA) (n,NA) (n,NA) (n,N3HE A) (n,P) (n,N) (n,G)
99Es250	(n,X\P) (n,X\T) (n,X\A) (n,PA) (n,2NA) (n,NA) (n,N3HE A) (n,ND 2NP) (n,P) (n,G)
99Es256m1	(n,X\A) (n,2NA) (n,NA) (n,A) (n,G)
99Es257	(n,X\A) (n,2NA) (n,NA) (n,A)
100Fm252	(n,X\P) (n,X\A) (n,2N2A) (n,N2A) (n,2A) (n,PA) (n,PA) (n,2NA) (n,NA) (n,N3HE A) (n,P) (n,G)
100Fm253	(n,X\P) (n,X\A) (n,2N2A) (n,N2A) (n,2A) (n,NPA DA) (n,NPA DA) (n,PA) (n,2NA) (n,NA) (n,N3HE A) (n,P) (n,G)
100Fm257	(n,X\P) (n,X\A) (n,2NA) (n,NA) (n,N3HE A) (n,P) (n,G)

APPENDIX B.

List of 1965 truncated reaction cross sections in the current CINDER2008 fusion-weighted library but fixed in the updated CINDER2008 fusion-weighted library.

Target Nucl.	Reactions
4Be7	(N,X\P) (n,X\A) (n,P) (n,G)
4Be10	(n,G)
6C12	(n,G)
6C13	(n,G)
6C14	(n,G)
8O18	(n,G)
10Ne20	(n,G)
10Ne21	(n,X\A) (n,A) (n,G)
10Ne22	(n,G)
11Na24	(n,G)
12Mg28	(n,G)
13Al26	(n,X\P) (n,X\A) (n,N3HE A PT) (n,P) (n,G)
14Si31	(n,G)
14Si32	(n,G)
15P32	(n,X\P) (n,P) (n,G)
15P33	(n,G)
16S35	(n,X\A) (n,A) (n,G)
17Cl36	(n,X\P) (n,X\A) (n,A PT) (n,P) (n,G)
18Ar37	(n,X\P) (n,X\A) (n,N3HE A PT) (n,P) (n,G)
18Ar39	(n,X\A) (n,A PT) (n,G)
18Ar41	(n,G)
18Ar42	(n,G)
19K42	(n,X\P) (n,P) (n,G)
19K43	(n,G)
20Ca41	(n,X\P) (n,X\A) (n,N3HE A PT) (n,P) (n,G)
20Ca45	(n,G)
20Ca47	(n,G)
21Sc44m1	(n,X\P) (n,X\A) (n,N3HE A PT) (n,P) (n,N) (n,G) (n,G)
21Sc46	(n,X\P) (n,P) (n,G)
21Sc47	(n,G)
21Sc48	(n,X\P) (n,P) (n,G)
22Ti44	(n,X\P) (n,X\A) (n,A PT) (n,P) (n,P) (n,G)
22Ti45	(n,X\P) (n,X\A) (n,N3HE A PT) (n,P) (n,P) (n,G)

Target Nucl.	**Reactions**
23V48	(n,X\P) (n,X\A) (n,A) (n,A) (n,P) (n,G)
23V49	(n,X\P) (n,P) (n,G)
24Cr48	(n,X\P) (n,X\A) (n,A) (n,P) (n,G)
24Cr51	(n,X\P) (n,X\A) (n,A PT) (n,P) (n,G)
25Mn52	(n,X\P) (n,X\A) (n,A PT) (n,P) (n,G)
25Mn53	(n,X\P) (n,P) (n,G)
25Mn54	(n,X\P) (n,X\A) (n,A) (n,P) (n,G)
26Fe52	(n,X\P) (n,X\A) (n,A PT) (n,P) (n,P) (n,G) (n,G)
26Fe55	(n,X\P) (n,X\A) (n,A PT) (n,P) (n,G)
26Fe60	(n,G)
27Co55	(n,X\P) (n,X\A) (n,A) (n,A) (n,P) (n,G)
27Co56	(n,X\P) (n,X\A) (n,N3HE A PT) (n,P) (n,G)
27Co57	(n,X\P) (n,X\A) (n,A) (n,P) (n,G) (n,G)
27Co60	(n,X\P) (n,P) (n,N) (n,G)
28Ni56	(n,X\P) (n,X\A) (n,N3HE PT A) (n,P) (n,G)
28Ni57	(n,X\P) (n,X\A) (n,N3HE A PT) (n,P) (n,G)
28Ni63	(n,G)
28Ni66	(n,G)
29Cu64	(n,X\P) (n,X\A) (n,A) (n,P) (n,G)
29Cu67	(n,G) (n,G)
30Zn62	(n,X\P) (n,X\A) (n,N3HE A PT) (n,P) (n,G)
30Zn69m1	(n,X\A) (n,A) (n,N) (n,G)
30Zn72	(n,G) (n,G) (n,G)
31Ga66	(n,X\P) (n,X\A) (n,N3HE A PT) (n,P) (n,G)
31Ga67	(n,X\P) (n,X\A) (n,A PT) (n,P) (n,G)
31Ga72	(n,X\P) (n,X\A) (n,PA) (n,A) (n,P) (n,G)
32Ge68	(n,X\P) (n,X\A) (n,A PT) (n,P) (n,G)
32Ge69	(n,X\P) (n,X\A) (n,N3HE A PT) (n,P) (n,G)
32Ge71	(n,X\P) (n,X\A) (n,N3HE A PT) (n,P) (n,G)
32Ge77	(n,G)
33As71	(n,X\P) (n,X\A) (n,A PT) (n,P) (n,P) (n,G)
33As72	(n,X\P) (n,X\A) (n,N3HE A PT) (n,P) (n,G)
33As73	(n,X\P) (n,X\A) (n,A) (n,P) (n,P) (n,G)
33As76	(n,X\P) (n,X\A) (n,A) (n,P) (n,G)
33As77	(n,G)
34Se72	(n,X\P) (n,X\A) (n,A PT) (n,P) (n,G) (n,G)
34Se73	(n,X\P) (n,X\A) (n,N3HE A PT) (n,P) (n,N) (n,G)
34Se75	(n,X\P) (n,X\A) (n,N3HE A PT) (n,P) (n,G)

Target Nucl.	Reactions
35Br76	(n,X\P) (n,X\A) (n,N3HE A PT) (n,P) (n,N) (n,G) (n,G)
35Br77	(n,X\P) (n,X\A) (n,A) (n,P) (n,P) (n,N) (n,G)
35Br82	(n,X\P) (n,P) (n,N) (n,G)
36Kr76	(n,X\P) (n,X\A) (n,A PT) (n,A PT) (n,P) (n,P) (n,G)
36Kr79	(n,X\P) (n,X\A) (n,N3HE A PT) (n,P) (n,P) (n,N) (n,G)
36Kr81	(n,X\P) (n,X\A) (n,A PT) (n,P) (n,G)
37Rb82m1	(n,X\P) (n,X\A) (n,A PT) (n,A PT) (n,P) (n,G)
37Rb83	(n,X\P) (n,P) (n,P) (n,G) (n,G)
37Rb84	(n,X\P) (n,X\3HE) (n,X\A) (n,A) (n,3HE) (n,P) (n,G)
38Sr82	(n,X\P) (n,X\A) (n,A) (n,A) (n,P) (n,P) (n,G) (n,G)
38Sr83	(n,X\P) (n,X\A) (n,N3HE A PT) (n,P) (n,G)
38Sr85	(n,X\P) (n,X\A) (n,A PT) (n,P) (n,G)
38Sr91	(n,G)
39Y86	(n,X\P) (n,X\A) (n,A PT) (n,P) (n,G) (n,G)
39Y87	(n,X\P) (n,P) (n,P) (n,G)
39Y87m1	(n,X\P) (n,X\A) (n,A) (n,P) (n,P) (n,N) (n,G)
39Y88	(n,X\P) (n,X\A) (n,A) (n,P) (n,G) (n,G)
39Y93	(n,G)
40Zr86	(n,X\P) (n,X\A) (n,A PT) (n,A) (n,P) (n,P) (n,G) (n,G)
40Zr88	(n,X\P) (n,X\A) (n,A) (n,A) (n,P) (n,G) (n,G)
40Zr89	(n,X\P) (n,X\A) (n,A PT) (n,P) (n,P) (n,G) (n,G)
40Zr97	(n,G)
41Nb90	(n,X\P) (n,X\A) (n,A PT) (n,A PT) (n,P) (n,P) (n,N) (n,G)
41Nb91	(n,X\P) (n,X\A) (n,A) (n,P) (n,N) (n,G) (n,G)
41Nb91m1	(n,X\P) (n,X\A) (n,A) (n,P) (n,N) (n,G) (n,G)
41Nb92	(n,X\P) (n,X\A) (n,N3HE A PT) (n,N3HE A PT) (n,P) (n,N) (n,G) (n,G)
41Nb92m1	(n,X\P) (n,X\A) (n,PA) (n,N3HE A PT) (n,N3HE A PT) (n,P) (n,N) (n,G) (n,G)
41Nb93m1	(n,X\P) (n,X\A) (n,A) (n,A) (n,P) (n,N) (n,G) (n,G)
41Nb95m1	(n,X\P) (n,X\A) (n,A) (n,P) (n,N) (n,G)
41Nb96	(n,X\A) (n,A) (n,A) (n,G) (n,G)
42Mo93	(n,X\P) (n,X\A) (n,N3HE A PT) (n,A PT) (n,P) (n,P) (n,G)
42Mo93m1	(n,X\P) (n,X\A) (n,N3HE A PT) (n,N3HE A PT) (n,P) (n,P) (n,G)
43Tc95	(n,X\P) (n,X\A) (n,A PT) (n,A PT) (n,P) (n,N) (n,G) (n,G)
43Tc95m1	(n,X\P) (n,X\A) (n,A PT) (n,A PT) (n,P) (n,N) (n,G) (n,G)
43Tc96	(n,X\P) (n,X\A) (n,N3HE A PT) (n,N3HE A PT) (n,P) (n,N) (n,G) (n,G)
43Tc97	(n,X\P) (n,X\A) (n,A) (n,A) (n,P) (n,N) (n,G)
43Tc97m1	(n,X\P) (n,X\A) (n,A) (n,A) (n,P) (n,N) (n,G)
43Tc98	(n,X\P) (n,X\A) (n,A) (n,A) (n,P) (n,G) (n,G)

Target Nucl.	Reactions
43Tc99m1	(n,X\A) (n,A) (n,G)
44Ru97	(n,X\P) (n,X\A) (n,N3HE A PT) (n,P) (n,P) (n,G)
45Rh99	(n,X\P) (n,X\A) (n,A PT) (n,A PT) (n,P) (n,N) (n,G) (n,G)
45Rh99m1	(n,X\P) (n,X\A) (n,A PT) (n,A PT) (n,P) (n,N) (n,G) (n,G)
45Rh100	(n,X\P) (n,X\A) (n,N3HE A PT) (n,N3HE A PT) (n,P) (n,N) (n,G) (n,G)
45Rh101	(n,X\P) (n,X\A) (n,A) (n,P) (n,G) (n,G)
45Rh101m1	(n,X\P) (n,X\A) (n,A) (n,P) (n,N) (n,G) (n,G)
45Rh102	(n,X\P) (n,X\3HE) (n,X\A) (n,A) (n,A) (n,3HE PD) (n,P) (n,N) (n,G) (n,G)
45Rh102m1	(n,X\P) (n,X\3HE) (n,X\A) (n,2NA) (n,A) (n,A) (n,3HE PD) (n,P) (n,N) (n,G) (n,G)
46Pd100	(n,X\P) (n,X\A) (n,N3HE A PT) (n,P) (n,P) (n,G)
46Pd101	(n,X\P) (n,X\A) (n,N3HE A PT) (n,P) (n,P) (n,G)
46Pd103	(n,X\P) (n,X\A) (n,N3HE A PT) (n,P) (n,P) (n,G)
46Pd109	(n,X\A) (n,A) (n,G)
46Pd112	(n,G) (n,G)
47Ag105	(n,X\P) (n,X\A) (n,A) (n,A) (n,P) (n,N) (n,G) (n,G)
47Ag106m1	(n,X\P) (n,X\A) (n,A PT) (n,A) (n,P) (n,N) (n,G) (n,G)
47Ag108m1	(n,X\P) (n,X\A) (n,A) (n,A) (n,P) (n,N) (n,G) (n,G)
48Cd107	(n,X\P) (n,X\A) (n,N3HE A PT) (n,P) (n,P) (n,G)
48Cd109	(n,X\P) (n,X\A) (n,A PT) (n,P) (n,P) (n,G)
48Cd113m1	(n,X\A) (n,A) (n,N) (n,G)
48Cd115	(n,X\A) (n,A) (n,G)
49In111	(n,X\P) (n,X\A) (n,A) (n,A) (n,P) (n,P) (n,G)
49In114m1	(n,X\P) (n,X\A) (n,A) (n,A) (n,P) (n,N) (n,G) (n,G)
50Sn117m1	(n,X\A) (n,A) (n,N) (n,G)
50Sn119m1	(n,X\A) (n,A) (n,N) (n,G)
50Sn121	(n,N) (n,G)
50Sn121m1	(n,N) (n,G)
51Sb119	(n,X\P) (n,X\A) (n,A) (n,A) (n,A) (n,P) (n,P) (n,G) (n,G)
51Sb120m1	(n,X\P) (n,X\A) (n,A) (n,A) (n,P) (n,N) (n,G)
51Sb122	(n,X\P) (n,X\A) (n,A) (n,A) (n,P) (n,G)
51Sb127	(n,G) (n,G)
51Sb128	(n,G) (n,G)
52Te118	(n,X\P) (n,X\A) (n,N3HE A PT) (n,P) (n,G) (n,G)
52Te119	(n,X\P) (n,X\A) (n,N3HE A PT) (n,P) (n,P) (n,G)
52Te119m1	(n,X\P) (n,X\A) (n,N3HE A PT) (n,P) (n,P) (n,N) (n,G)
52Te121	(n,X\P) (n,X\A) (n,N3HE A PT) (n,P) (n,G)
52Te121m1	(n,X\P) (n,X\A) (n,N3HE A PT) (n,P) (n,N) (n,G)
52Te123m1	(n,X\P) (n,X\A) (n,A PT) (n,P) (n,N) (n,G)

Target Nucl.	Reactions
52Te125m1	(n,X\A) (n,A) (n,N) (n,G)
52Te127	(n,X\A) (n,A) (n,N) (n,G)
52Te129	(n,X\A) (n,A) (n,N) (n,G)
52Te131m1	(n,N) (n,G)
53I123	(n,X\P) (n,X\A) (n,A) (n,A) (n,P) (n,P) (n,G)
53I124	(n,X\P) (n,X\A) (n,N3HE A PT) (n,P) (n,G)
53I125	(n,X\P) (n,X\3HE) (n,X\A) (n,A) (n,A) (n,3HE PD) (n,P) (n,P) (n,G)
53I126	(n,X\P) (n,X\A) (n,A) (n,P) (n,G)
53I128	(n,X\P) (n,X\A) (n,A) (n,P) (n,G)
53I133	(n,G) (n,G)
54Xe122	(n,X\P) (n,X\A) (n,A PT) (n,A PT) (n,P) (n,G)
54Xe125	(n,X\P) (n,X\A) (n,N3HE A PT) (n,P) (n,G)
54Xe127	(n,X\P) (n,X\A) (n,A PT) (n,3HE PD) (n,P) (n,G)
54Xe129m1	(n,X\P) (n,X\A) (n,A) (n,P) (n,N) (n,G)
54Xe131m1	(n,X\P) (n,X\A) (n,A) (n,P) (n,N) (n,G)
54Xe133m1	(n,X\A) (n,A) (n,N) (n,G) (n,G)
55Cs127	(n,X\P) (n,X\A) (n,A) (n,P) (n,P) (n,G)
55Cs129	(n,X\P) (n,X\A) (n,PA) (n,A) (n,P) (n,P) (n,G) (n,G)
55Cs131	(n,X\P) (n,X\A) (n,A) (n,P) (n,P) (n,G)
55Cs132	(n,X\P) (n,X\A) (n,A) (n,P) (n,G)
56Ba128	(n,X\P) (n,X\A) (n,A PT) (n,A PT) (n,P) (n,G) (n,G)
56Ba129	(n,X\P) (n,X\A) (n,N3HE A PT) (n,P) (n,N) (n,G)
56Ba131	(n,X\P) (n,X\A) (n,N3HE A PT) (n,P) (n,G)
56Ba133m1	(n,X\P) (n,X\A) (n,A PT) (n,3HE PD) (n,P) (n,N) (n,G)
56Ba135m1	(n,X\P) (n,X\A) (n,A) (n,P) (n,N) (n,G) (n,G)
56Ba139	(n,X\A) (n,A) (n,G)
57La135	(n,X\P) (n,X\A) (n,PA) (n,A) (n,P) (n,P) (n,G) (n,G)
57La137	(n,X\P) (n,X\A) (n,A) (n,A) (n,P) (n,G)
57La141	(n,X\A) (n,A) (n,A) (n,G)
58Ce134	(n,X\P) (n,X\A) (n,A PT) (n,A PT) (n,P) (n,G) (n,G)
58Ce135	(n,X\P) (n,X\A) (n,N3HE A PT) (n,P) (n,G)
58Ce137	(n,X\P) (n,X\A) (n,N3HE A PT) (n,P) (n,G)
58Ce137m1	(n,X\P) (n,X\A) (n,N3HE A PT) (n,P) (n,N) (n,G)
60Nd140	(n,X\P) (n,X\A) (n,PA) (n,PA) (n,A) (n,A) (n,P) (n,G) (n,G)
60Nd141	(n,X\P) (n,X\A) (n,N3HE A PT) (n,P) (n,G)
60Nd149	(n,X\A) (n,A) (n,G)
61Pm143	(n,X\P) (n,X\A) (n,A) (n,P) (n,G)
61Pm144	(n,X\P) (n,X\A) (n,N3HE A PT) (n,P) (n,G)

Target Nucl.	**Reactions**
61Pm145	(n,X\P) (n,X\A) (n,A) (n,A) (n,P) (n,G)
61Pm146	(n,X\P) (n,X\A) (n,2A) (n,N3HE A) (n,P) (n,G)
61Pm150	(n,X\A) (n,A) (n,G)
62Sm145	(n,X\P) (n,X\A) (n,N3HE A PT) (n,P) (n,G)
62Sm146	(n,X\A) (n,A) (n,G)
62Sm156	(n,G)
63Eu145	(n,X\P) (n,X\A) (n,A PT) (n,P) (n,G)
63Eu146	(n,X\P) (n,X\A) (n,NPA DA) (n,PA) (n,N3HE A PT) (n,P) (n,G)
63Eu147	(n,X\P) (n,X\A) (n,N3HE A PT) (n,P) (n,G)
63Eu148	(n,X\P) (n,X\A) (n,2A) (n,N3HE A PT) (n,P) (n,G)
63Eu149	(n,X\P) (n,X\A) (n,A) (n,P) (n,G) (n,G)
63Eu150	(n,X\P) (n,X\A) (n,N3HE A) (n,P) (n,N) (n,G)
63Eu150m1	(n,X\P) (n,X\A) (n,N3HE A PT) (n,P) (n,N) (n,G)
63Eu152m1	(n,X\P) (n,X\A) (n,A) (n,P) (n,N) (n,N) (n,G)
64Gd146	(n,X\P) (n,X\A) (n,A PT) (n,P) (n,G)
64Gd147	(n,X\P) (n,X\A) (n,2A) (n,N3HE A PT) (n,P) (n,G)
64Gd148	(n,X\A) (n,N3HE A PT) (n,G)
64Gd149	(n,X\P) (n,X\A) (n,2A) (n,N3HE A PT) (n,P) (n,G)
64Gd150	(n,X\A) (n,N3HE A PT) (n,G)
64Gd151	(n,X\P) (n,X\A) (n,2A) (n,N3HE A PT) (n,P) (n,G)
64Gd159	(n,X\A) (n,A) (n,G)
65Tb151	(n,X\P) (n,X\A) (n,2A) (n,N3HE A PT) (n,P) (n,N) (n,G) (n,G)
65Tb152	(n,X\P) (n,X\A) (n,2A) (n,N3HE A PT) (n,P) (n,G)
65Tb153	(n,X\P) (n,X\A) (n,A) (n,A) (n,P) (n,G) (n,G) (n,G)
65Tb154	(n,X\P) (n,X\A) (n,TA) (n,NPA DA) (n,N3HE A PT) (n,P) (n,G)
65Tb154m1	(n,X\P) (n,X\A) (n,2A) (n,N3HE A PT) (n,3HE PD) (n,P) (n,G)
65Tb154m2	(n,X\P) (n,X\A) (n,2A) (n,N3HE A PT) (n,3HE PD) (n,P) (n,N) (n,N) (n,G)
65Tb155	(n,X\P) (n,X\A) (n,A) (n,A) (n,A) (n,P) (n,G) (n,G) (n,G)
65Tb156	(n,X\P) (n,X\A) (n,A) (n,P) (n,N) (n,N) (n,G)
65Tb156m1	(n,X\P) (n,X\A) (n,A) (n,P) (n,N) (n,N) (n,G)
65Tb156m2	(n,X\P) (n,X\A) (n,A) (n,P) (n,N) (n,N) (n,G)
65Tb157	(n,X\A) (n,A) (n,A) (n,G)
65Tb158	(n,X\P) (n,X\A) (n,A) (n,P) (n,N) (n,G)
65Tb161	(n,X\A) (n,A) (n,G)
66Dy153	(n,X\P) (n,X\A) (n,2N2A) (n,2A) (n,TA) (n,N3HE A PT) (n,P) (n,G)
66Dy155	(n,X\P) (n,X\A) (n,2A) (n,N3HE A PT) (n,P) (n,G)
66Dy157	(n,X\P) (n,X\A) (n,N3HE A PT) (n,P) (n,G)
66Dy165	(n,X\A) (n,A) (n,N) (n,G)

Target Nucl.	Reactions
66Dy166	(n,G)
67Ho163	(n,X\A) (n,2NA) (n,A) (n,G) (n,G)
67Ho164	(n,X\P) (n,X\A) (n,A) (n,P) (n,N) (n,G)
67Ho164m1	(n,X\P) (n,X\A) (n,A) (n,P) (n,N) (n,G)
67Ho166	(n,X\A) (n,A) (n,N) (n,G)
67Ho166m1	(n,X\A) (n,A) (n,N) (n,G)
68Er160	(n,X\P) (n,X\A) (n,A) (n,P) (n,G)
68Er161	(n,X\P) (n,X\A) (n,N3HE A PT) (n,P) (n,P) (n,G)
68Er165	(n,X\A) (n,A) (n,G)
68Er169	(n,X\A) (n,A) (n,G)
68Er171	(n,X\A) (n,A) (n,G)
68Er172	(n,2NA) (n,G)
69Tm165	(n,X\P) (n,X\A) (n,2NA) (n,A) (n,A) (n,P) (n,G)
69Tm166	(n,X\P) (n,X\A) (n,N3HE A) (n,A) (n,P) (n,G)
69Tm167	(n,X\P) (n,X\3HE) (n,X\A) (n,A) (n,A) (n,3HE) (n,P) (n,P) (n,G)
69Tm168	(n,X\P) (n,X\3HE) (n,X\A) (n,A) (n,3HE) (n,P) (n,G)
69Tm170	(n,X\A) (n,A) (n,G)
69Tm171	(n,X\A) (n,A) (n,A) (n,G)
69Tm172	(n,X\P) (n,X\A) (n,A) (n,P) (n,G)
69Tm173	(n,X\A) (n,2NA) (n,A) (n,A) (n,G)
70Yb166	(n,X\A) (n,A) (n,G)
70Yb169	(n,X\P) (n,X\A) (n,N3HE A PT) (n,3HE) (n,P) (n,N) (n,G)
70Yb175	(n,X\A) (n,A) (n,G) (n,G)
71Lu169	(n,X\P) (n,X\A) (n,A) (n,P) (n,P) (n,N) (n,G) (n,G)
71Lu170	(n,X\P) (n,X\A) (n,N3HE A PT) (n,P) (n,N) (n,G) (n,G)
71Lu171	(n,X\P) (n,X\A) (n,A) (n,P) (n,N) (n,G)
71Lu172	(n,X\P) (n,X\A) (n,N3HE A) (n,P) (n,N) (n,G)
71Lu173	(n,X\P) (n,X\A) (n,A) (n,P) (n,G) (n,G)
71Lu174	(n,X\P) (n,X\A) (n,A) (n,P) (n,G)
71Lu174m1	(n,X\P) (n,X\A) (n,A) (n,P) (n,N) (n,G)
71Lu177	(n,X\A) (n,A) (n,G) (n,G)
71Lu177m1	(n,X\A) (n,A) (n,N) (n,G) (n,G)
72Hf170	(n,X\P) (n,X\A) (n,N3HE A PT) (n,P) (n,P) (n,G) (n,G)
72Hf171	(n,X\P) (n,X\A) (n,2A) (n,N3HE A PT) (n,P) (n,P) (n,G)
72Hf172	(n,X\A) (n,A) (n,A) (n,G)
72Hf173	(n,X\P) (n,X\A) (n,N3HE A PT) (n,P) (n,G)
72Hf175	(n,X\P) (n,X\A) (n,N3HE A) (n,P) (n,G)
72Hf178m2	(n,X\A) (n,A) (n,N) (n,N) (n,G) (n,G)

Target Nucl.	Reactions
72Hf179m2	(n,X\A) (n,A) (n,A) (n,N) (n,N) (n,G) (n,G)
72Hf180m1	(n,X\A) (n,A) (n,A) (n,N) (n,G)
73Ta175	(n,X\P) (n,X\A) (n,NPA DA) (n,A) (n,P) (n,G)
73Ta176	(n,X\P) (n,X\A) (n,N2A) (n,N3HE A PT) (n,P) (n,G)
73Ta177	(n,X\P) (n,X\A) (n,A) (n,A) (n,P) (n,P) (n,G)
73Ta179	(n,X\A) (n,A) (n,A) (n,G) (n,G)
73Ta180	(n,X\P) (n,X\A) (n,A) (n,A) (n,A) (n,P) (n,N) (n,G)
73Ta180m1	(n,X\A) (n,A) (n,A) (n,A) (n,N) (n,G)
73Ta183	(n,X\A) (n,A) (n,A) (n,G)
73Ta184	(n,X\A) (n,A) (n,G)
74W178	(n,X\A) (n,A) (n,G) (n,G)
74W181	(n,X\A) (n,A) (n,A) (n,A) (n,G)
74W185	(n,X\A) (n,A) (n,A) (n,G)
74W187	(n,X\A) (n,A) (n,A) (n,G)
74W188	(n,X\A) (n,A) (n,G)
75Re181	(n,X\P) (n,X\A) (n,A) (n,P) (n,G) (n,G)
75Re182	(n,X\P) (n,X\A) (n,N3HE A) (n,P) (n,N) (n,G)
75Re182m1	(n,X\P) (n,X\A) (n,N3HE A PT) (n,P) (n,N) (n,G)
75Re183	(n,X\A) (n,A) (n,A) (n,G) (n,G)
75Re184	(n,X\P) (n,X\A) (n,A) (n,P) (n,G)
75Re184m1	(n,X\P) (n,X\A) (n,A) (n,P) (n,N) (n,G)
75Re186	(n,X\A) (n,A) (n,G)
75Re186m1	(n,X\A) (n,A) (n,N) (n,G)
75Re188	(n,X\A) (n,A) (n,G)
75Re189	(n,X\A) (n,A) (n,G) (n,G)
76Os182	(n,X\A) (n,A) (n,A) (n,G) (n,G)
76Os183	(n,X\P) (n,X\A) (n,N3HE A PT) (n,P) (n,G)
76Os183m1	(n,X\P) (n,X\A) (n,N3HE A PT) (n,P) (n,G)
76Os185	(n,X\P) (n,X\A) (n,N3HE A) (n,P) (n,G)
76Os191	(n,X\A) (n,A) (n,N) (n,G) (n,G)
76Os191m1	(n,X\A) (n,A) (n,N) (n,G) (n,G)
76Os193	(n,X\A) (n,A) (n,G)
76Os194	(n,G)
77Ir185	(n,X\P) (n,X\A) (n,A) (n,A) (n,P) (n,G) (n,G)
77Ir186	(n,X\P) (n,X\A) (n,N3HE A PT) (n,P) (n,N) (n,G)
77Ir187	(n,X\P) (n,X\A) (n,A) (n,A) (n,2P) (n,P) (n,G)
77Ir188	(n,X\P) (n,X\A) (n,N3HE A) (n,P) (n,G)
77Ir189	(n,X\A) (n,A) (n,A) (n,G)

Target Nucl.	**Reactions**
77Ir190	(n,X\P) (n,X\A) (n,A) (n,P) (n,P) (n,N) (n,N) (n,G) (n,G)
77Ir192	(n,X\P) (n,X\A) (n,A) (n,P) (n,N) (n,G) (n,G)
77Ir192m2	(n,X\A) (n,A) (n,P) (n,N) (n,N) (n,G) (n,G)
77Ir193m1	(n,X\A) (n,A) (n,A) (n,N) (n,G) (n,G) (n,G)
77Ir194	(n,X\A) (n,A) (n,G) (n,G)
77Ir194m2	(n,X\P) (n,X\A) (n,NA) (n,NA) (n,A) (n,P) (n,N) (n,N) (n,G) (n,G)
77Ir196m1	(n,X\A) (n,A) (n,N) (n,G) (n,G)
78Pt188	(n,X\A) (n,A) (n,G)
78Pt189	(n,X\P) (n,X\A) (n,2A) (n,N3HE A PT) (n,P) (n,G)
78Pt190	(n,X\A) (n,A) (n,G)
78Pt191	(n,X\P) (n,X\A) (n,N3HE A) (n,P) (n,G)
78Pt192	(n,X\A) (n,A) (n,A) (n,G) (n,G)
78Pt193	(n,X\A) (n,A) (n,A) (n,G)
78Pt193m1	(n,X\A) (n,A) (n,A) (n,N) (n,G)
78Pt194	(n,X\A) (n,A) (n,A) (n,G) (n,G)
78Pt195	(n,X\A) (n,A) (n,A) (n,G)
78Pt195m1	(n,X\A) (n,A) (n,A) (n,P) (n,N) (n,G)
78Pt196	(n,X\A) (n,A) (n,G) (n,G)
78Pt197	(n,X\A) (n,A) (n,G)
78Pt198	(n,G) (n,G)
78Pt200	(n,G)
78Pt202	(n,G)
79Au193	(n,X\P) (n,X\A) (n,A) (n,P) (n,G) (n,G) (n,G)
79Au194	(n,X\P) (n,X\A) (n,A) (n,A) (n,A) (n,P) (n,N) (n,G) (n,G)
79Au195	(n,X\A) (n,2NA) (n,A) (n,A) (n,A) (n,2P) (n,G) (n,G)
79Au196	(n,X\P) (n,X\A) (n,2NA) (n,A) (n,A) (n,P) (n,N) (n,N) (n,G) (n,G)
79Au196m2	(n,X\A) (n,A) (n,A) (n,G) (n,G)
79Au198	(n,X\A) (n,A) (n,A) (n,G)
79Au198m1	(n,X\A) (n,A) (n,A) (n,N) (n,G)
79Au199	(n,G) (n,G)
79Au200m1	(n,X\A) (n,A) (n,A) (n,N) (n,G)
80Hg193	(n,X\P) (n,X\A) (n,N3HE A PT) (n,P) (n,P) (n,N) (n,G)
80Hg193m1	(n,X\P) (n,X\A) (n,N3HE A PT) (n,P) (n,P) (n,N) (n,G)
80Hg194	(n,X\A) (n,A) (n,G) (n,G)
80Hg195	(n,X\P) (n,X\3HE) (n,X\A) (n,A) (n,3HE) (n,P) (n,P) (n,G)
80Hg195m1	(n,X\P) (n,X\A) (n,A) (n,P) (n,P) (n,N) (n,G)
80Hg197	(n,X\A) (n,A) (n,G)
80Hg197m1	(n,X\A) (n,A) (n,N) (n,G)

Target Nucl.	Reactions
80Hg203	(n,X\A) (n,A) (n,G)
81Tl199	(n,X\P) (n,X\A) (n,2NA) (n,A) (n,A) (n,A) (n,P) (n,G)
81Tl200	(n,X\P) (n,X\A) (n,A) (n,A) (n,P) (n,G)
81Tl201	(n,X\A) (n,A) (n,A) (n,G)
81Tl202	(n,X\P) (n,X\A) (n,A) (n,P) (n,G)
81Tl203	(n,X\A) (n,A) (n,A) (n,G)
81Tl204	(n,X\A) (n,A) (n,G)
81Tl205	(n,G) (n,G)
82Pb200	(n,X\P) (n,X\A) (n,A) (n,A) (n,P) (n,G) (n,G)
82Pb201	(n,X\P) (n,X\A) (n,A) (n,3HE) (n,P) (n,G) (n,G)
82Pb202	(n,X\3HE) (n,X\A) (n,2NA) (n,A) (n,A) (n,3HE) (n,G)
82Pb203	(n,X\P) (n,X\A) (n,A) (n,P) (n,G) (n,G)
82Pb205	(n,X\A) (n,A) (n,G)
82Pb209	(n,X\A) (n,A) (n,G)
82Pb210	(n,X\A) (n,A) (n,G)
82Pb212	(n,X\A) (n,A) (n,G)
83Bi203	(n,X\P) (n,X\A) (n,A) (n,P) (n,P) (n,P) (n,G)
83Bi204	(n,X\P) (n,X\A) (n,A) (n,P) (n,P) (n,G)
83Bi205	(n,X\P) (n,X\A) (n,A) (n,P) (n,P) (n,G)
83Bi206	(n,X\P) (n,X\A) (n,A) (n,P) (n,G)
83Bi207	(n,X\P) (n,X\A) (n,A) (n,P) (n,G) (n,G)
83Bi208	(n,X\P) (n,X\A) (n,A) (n,P) (n,G)
83Bi210	(n,X\A) (n,N3HE A) (n,A) (n,G)
83Bi210m1	(n,X\A) (n,N3HE A) (n,A) (n,N) (n,G)
84Po206	(n,X\P) (n,X\A) (n,A) (n,A) (n,A) (n,P) (n,G) (n,G)
84Po207	(n,X\P) (n,X\A) (n,N3HE A PT) (n,N3HE A PT) (n,P) (n,G)
84Po208	(n,X\P) (n,X\A) (n,N3HE A PT) (n,N3HE A PT) (n,P) (n,P) (n,G)
84Po209	(n,X\P) (n,X\A) (n,N3HE A PT) (n,P) (n,G)
84Po210	(n,X\A) (n,N3HE A) (n,A) (n,G) (n,G)
85At210	(n,X\P) (n,X\A) (n,2A) (n,PA) (n,NA) (n,N3HE A PT) (n,P) (n,G)
85At211	(n,X\A) (n,NA) (n,N3HE A PT) (n,N3HE A PT) (n,2P) (n,G) (n,G)
86Rn211	(n,X\P) (n,X\A) (n,2A) (n,2A) (n,NA) (n,NA) (n,N3HE A PT) (n,P) (n,G)
86Rn222	(n,X\A) (n,2NA) (n,A) (n,G)
88Ra228	(n,X\A) (n,A) (n,G)
89Ac228	(n,X\A) (n,A) (n,G)
91Pa228	(n,X\P) (n,X\A) (n,N3A) (n,N2A) (n,2A) (n,NA) (n,N3HE A) (n,P) (n,G)
91Pa234	(n,X\A) (n,A) (n,G)
93Np236m1	(n,X\A) (n,A) (n,G)

Target Nucl.	Reactions
94Pu234	(n,X\A) (n,2A) (n,NA) (n,A) (n,G)
94Pu245	(n,X\A) (n,2NA) (n,A) (n,G)
94Pu247	(n,X\A) (n,A)
95Am239	(n,X\A) (n,A) (n,A) (n,G)
97Bk248m1	(n,X\A) (n,A) (n,N) (n,G)
99Es250	(n,X\P) (n,X\A) (n,NA) (n,A) (n,P) (n,G)
99Es256m1	(n,X\A) (n,DA) (n,NA) (n,A) (n,G)
99Es257	(n,X\A) (n,A)
100Fm252	(n,X\A) (n,2A) (n,NA) (n,A) (n,G)
100Fm253	(n,X\A) (n,2A) (n,NA) (n,N3HE A) (n,G)
100Fm257	(n,X\P) (n,X\A) (n,NA) (n,A) (n,P) (n,G)